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Science Education

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Editorial Notes and Comments

Foreign Editors of Science Education

Intelligent interchange of ideas concerning the philosophy and practices of the teaching of science in this and foreign countries should lead to greater clarity, purposefulness, and effectiveness in the program for teaching science. With this thought in mind, the Editorial Board has invited several leaders from the field of science education in foreign countries to join the staff of editors of *Science Education*. We are greatly pleased to introduce to our readers three men, scientists and teachers, who have accepted our invitation to become foreign editors and who have expressed their willingness to submit occasional notes and articles characterizing interesting advances in science education in their respective countries.

Dr. Otakar Matoušek, Professor of Earth Science in Education, Charles University, Prague, Czechoslovakia, is an active leader in formulating and developing science education in his country. Dr. Matoušek recently spent one year in America making a study of our educational system and is at present connected with the Open-Air School of Geography and Science in Education of Charles University. His special science field is geology.

Mr. F. W. Turner, M.A., M.Sc., M.R.S.T., Senior Science Master of the Thames Valley County School, Twickenham, Middlesex, England, is our foreign editor in England. Mr. Turner has had a brilliant academic career in the fields of chemistry and education at the University of London having received various research fellowships. His last fellowship brought him to America where he made the teaching of general science the subject of his research.

Dr. Karl von Hollander, Professor an der Pädagogischen Akademie, Halle, Germany, will represent his country on our staff. Dr. von Hollander is one of the outstanding men in the field of science education in Germany and has been a leader in the reorganization of science education in teacher-training institutions. Biology is his subject-matter field.

Suggestions for Projects in a Local Activities Program

In the April issue of *Science Education,* Dr. Edward E. Wildman, Director of Science Education, Philadelphia, and Chairman of the William Penn Planning Committee, gave a brief description of plans for living memorials to William Penn. The School Committee on Penn Memorials has recently published its report in two pamphlets entitled *William Penn and the Delaware Indians* and *On the National History of William Penn's Delaware Valley and Ours.* These pamphlets, particularly the second which is Part II of the Committee's report, will be of especial interest to teachers of elementary science.

The general purpose and plan of the Committee's work appears to be laden with suggestions for teachers and administrators of science courses in other communities that we quote from the preface of the report:

> At its meeting of organization held at the Academy of Natural Sciences in April, the committee gave itself the name of THE SCHOOLS COMMITTEE ON PENN MEMORIALS, and set up certain goals to work for as living memorials to Penn, in which the boys and girls of our schools can participate. The following were chosen, and have been studied by sub-committees during the year:
>
> (a) A study of the Indians of the Valley in Penn's day, and of our present national Indian policy.
>
> (b) Locating trees which are survivors of "Penn's Woods," and securing seedlings from these, and planting them as Penn Memorial Trees.
>
> (c) A study of local natural history throughout the Valley,—plants, animals, minerals and fossils.
>
> (d) A study of present and proposed parks, wild life sanctuaries and Penn Memorial hiking trails for nature study, these to be laid out along old Indian trails where possible.
>
> (e) Illuminating by radio portraits of Penn in Christ Church College Common, Oxford, England, and here in Philadelphia on October 24, using as the initial energy the light of a star 250 light years away. This interesting and wholly unique project is under the care of the Franklin Institute of Philadelphia.

The Method and Content of Science Teaching in France

R. Beatrice Miller
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In France, education is a public service and must give to each individual the things he must know for adult life. There is uniformity, the outcome of centralization. Knowledge and information are stressed but also observation and experimentation. The appeal to logic and reason permeates the whole school atmosphere. Training in abstract thinking is emphasized as early as the upper elementary school.

A French elementary school is a six-year course preceded by a preparatory division of one year. There are three divisions of two years each, the elementary, the middle, and the upper course. It prepares for agricultural, industrial, and commercial life. It prepares for the higher primary schools which prepare for normal schools and for the great national technical schools. At the end of the six years in the elementary school, an examination is conducted which entitles the pupil to the *certificat d'études élémentaires*. In most cases this completes the education of the student. The examination is held in the capital of a canton and is conducted by a cantonal commission. It is both oral and written. The written examination consists of an essay, dictation and questions on language, reasoning problems in arithmetic and the metric system, an essay on history, geography, or science, as applied to the local industries, and an exercise in drawing or handwork. The oral examination consists of reading, recitation of a poem, a song, a problem in mental arithmetic, and some simple physical exercise.

A brief sketch of the administration gives background for the understanding of the curriculum. In France, there is extreme centralization. There is a Minister of Public Instruction and Fine Arts, a Ministry with four divisions: higher education, secondary education, elementary education, and finance. Each division is under a director and each division is divided into bureaus. The bureaus in the Division of Primary Education are (1) Personnel, (2) Discipline, Programmes, and Examinations, (3) Schools and School supplies, (4) Teaching Force, (5) Normal Schools and Scholarships. The Ministry has the advice of twelve general inspectors. For the sake of educational administration, France is divided into 17 academies (each with one exception has a university), 90 departments (the prefect in each department is the head of the elementary school), and 38,000

communes. About twelve communes represent a canton, the delegates of which supervise the material welfare and finance of the schools. The aim is to make education a public service and to promote uniformity.

In France, the program for science is outlined lesson by lesson with the stipulation that method must be observation and experimentation, and that even the program must be modified rather than give object lessons without objects. Courses are standardized but not method for there is to be free exchange of ideas between pupil and teacher. There is appreciation of the fact that content must be modified to adapt it to the needs of pupils, their environment, their sex, and their future occupations. There is a realization that the present course is not suitable for girls' schools and for rural schools because it is not adapted to housekeeping and agriculture. Physical and natural science are taught throughout the entire course.

The outlines on first reading seem miscellaneous but on careful study it is observed that many of the concepts and experiences in the early years are used in later lessons. In the preparatory section the child is taught fruits (grape, apple, and nut) and a few trees, such as oak and chestnut. In the elementary course, the child has object lessons on grains and vegetables. This is utilized in the study of orchard fruits and cereals in the middle and upper courses and in the physiological study of the functions of the plant. Nutrition and other aspects of hygiene run through the entire course. In the preparatory group, nutrition is associated with a piece of bread and a grain of wheat. This object work is followed by a superficial study of digestion in the elementary course and a study of important food plants in the following years. Less concrete work is introduced in the middle course such as the states of matter and some of the laws of heat. These laws of heat are utilized in the many discussions of the uses of matter. The upper course is concerned with the soils and the rocks from which they are formed. The soils of the region are studied and the problems of drainage and irrigation. Reference to the work in agriculture is made for the subject matter of each year. When the vegetables are studied, there is a recommendation for observation of the work in the field: when the meadow plants are studied there are directions to observe plowing, weeding, and harvesting.

Extensive references are made to domestic science and many practical exercises are listed. Definite reference is first made at the beginning of the upper course. The study of rocks is associated with methods of cleaning and polishing by powders. The vegetable study is associated with the preparation of foods and the cost of menus. Practical exercises are given in both cooking and cleaning. There are such exercises as sweeping floors,

cleaning table silver, and removing stains. At the end of the upper course there is provision for training the judgment of the quality of foods, as well as practical exercises in cooking. There are elementary lessons in the care of a child, worked out to include practical details.

Science is important in the continuation classes. These classes go back to the Revolution but have had slow growth. Since 1895, anyone can open a class who has the approval of the Mayor, the Prefect, and the Academy Inspector. Many practical subjects are given, but in the country schools agriculture holds first place and there is a large election of geography, the metric system, science, and hygiene. Recently state aid is taking the place of voluntary aid and the *cours d'adultes* is being developed, aided by popular lectures, moving pictures, radio, and popular libraries. Since 1919 there have been vocational courses with compulsory attendance.

The higher primary school, a three year course, prepares the pupils to pass the examination for the *brevet élémentaire*, which admits to the normal schools. A few students get the *certificat d'études primaires supérieures*, which is required for the great national technical schools. In the first series of examinations for the *brevet élémentaire*, physical and natural science is given the coefficient 2. No subject is given a higher coefficient except French composition, which is weighted 3. In the second series of examinations, taken a year later, physical and natural science is given a coefficient 2 and no subject is given a higher coefficient. The sciences recognized are physics, chemistry, and a combined course of geology, botany, zoölogy, and hygiene known as *sciences naturelles, hygiène*. The physics course includes the study of thermometry and calorimetry and the study of forces in the first year; gases, vaporization, mirrors and lenses in the second; electricity, magnetism, and a little sound in the third. The work in electricity includes chiefly electrostatics, eletrolysis, and electrical measurement. In chemistry the first year includes the study of air with emphasis on combustion, the study of water, the study of hydrogen, ammonia, sulphur, sodium, and a few acids. In the second year there is the study of the metals and work on symbols and formulas, and in the third, a study the well-known organic products and the process of fermentation. The geology course emphasizes the action of air, water, and glaciers on the rocks, the interaction of the living and physical world, and the practical applications of geology to agriculture and hygiene. The botany is a brief survey of the gymnosperms and angiosperms. The zoölogy selects some of the invertebrate groups, the worms, mollusks, and crustaceans, and surveys all the groups of vertebrates. In the third year, the physiology of plants and animals is given. It is a discussion of the functions of life

processes, circulation, respiration, digestion, photosynthesis, germination, etc. This is followed by a practical course in hygiene, with a discussion of infections and food dangers.

The science in the six years of secondary-school teaching is defined by the requirements of the *baccalauréat,* an examination in two sections, required for all at the end of the secondary-school period. In the first part of the examination, the student elects Series, A, A′, or B. All require a written examination in physics counting 3, and oral questions in physical science counting 4. No subject receives a higher coefficient than 4. In the second part of the examination, the choice is philosophy or mathematics. In philosophy there is required a composition on the physical and natural sciences counting 2, oral questions on physical and natural sciences counting 2 and 1. In mathematics a composition on the physical sciences counts 6 and the questions on physical and natural sciences 6 and 2. Geography is also required in both parts of all sections of the examination.

The method and content of the physical sciences is definitely outlined in the examination pamphlet. The purpose of the physical sciences is initiation into the experimental method. The lack of scientific material is deplored and recognition is given to the heavy load of preparation for the teachers. Mathematics is regarded as an important auxiliary but emphasis is placed on the importance of making the students reason and observe. In chemistry teachers are warned against the use of too many facts, unless bonds are established between them. The most important thing is the coherent whole. Practical exercises take up one and a half hours per week. Uniformity is recommended for chemistry but variation is recognized for physics because of the needs of equipment. Two types of exercises are described: those in which a constant is determined, for example, density, and those in which a law is deduced. The greater educative value of the latter type is recognized. The teaching of the natural sciences is not for verbal knowledge but for "intellectual discipline and education of judgment." The object of the lessons will be a plant or animal to be observed by the pupils. Diagrams and summaries are recommended. Directed work and observation must be given a half hour weekly or an hour every fortnight.

In the first section of the examination, the content of physics is drawn from heat, mechanics, optics, magnetism and electricity. There is much work on forces, equilibrium, changes produced by heat. In optics the emphasis is on mirrors, lenses, and optical instruments. In electricity there is emphasis on measurement and on the magnetic and chemical effects of current. Chemistry consists of the general laws, symbols, and formulas, the

most common elements in nature, such as oxygen and carbon, some acids and some metals. A little organic chemistry is given. In the second part of the examination, periodic motion and resonance are required, sound and interference, radiations such as cathode rays and X-rays. In the mathematical section, there is in addition much work on motion, composition of forces and machines. There is also an application of these laws of motion to the movements of planets, which leads far into cosmography. In chemistry the work includes the classification of acids, bases, and salts and the discussion of atomic laws. In the mathematical section there is more work on organic chemistry. The study of the natural sciences includes the study of functions of relation and functions of nutrition, for example, the muscles, nervous system, digestion, circulation, etc. In the plant anatomy and physiology all facts center around nutrition and reproduction. The course closes with a discussion of evolution. The same course is given for both the philosophy and mathematics section.

The French student, therefore, has much science over a long period of time. Certain concepts are given to all students. There is standardization in regard to these concepts but not in regard to the use of materials. The first emphasis is on knowledge but constantly there is the reiteration that this knowledge must come through the object lesson or experimental method.

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Sound Pictures in Elementary Science

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Erpi Picture Consultants, Inc., New York

All groups of educators have recognized the special advantages talking pictures offer the teaching of science. The teachers of science have been among the first to accept and advocate sound pictures as an integral part of classroom activities. They were also among the chief sponsors of the silent film a decade and a half ago. The scientific attitude and training of these people in a large measure account for spontaneous acceptance of this new mechanical aid to effective teaching and learning. Of course many teachers who are convinced of the value of this new medium have not yet been able to avail themselves of its special advantages because of factors beyond their control.

Were education a business in which the results or outcomes could be measured as profits in terms of dollars and cents the governing boards would consider more carefully methods of securing maximum educational outcome at minimum cost. However, the products of education are largely intangible and can be inventoried only in part by the best of available measuring devices. On the basis of those elements of instruction that at present lend themselves to measurement, the talking picture has demonstrated its value. The teachers participating in the sound-film experiment in the schools of Middlesex, England, were enthusiastic about the potentialities of this medium. More comprehensive experiments using the control technique in determining the value of talking pictures in science education are now under way. The University Film Foundation, Cambridge, Massachusetts, is investigating this contribution to science on the junior-high-school level, while Erpi Picture Consultants, Inc., New York, is making a study of sound pictures in science teaching as applied to the intermediate grades of the elementary school. Published results of both of these studies will soon be available.

Attaining the Objectives of Science

Outstanding advantages have been found for the talking picture in imparting information, knowledge, and understanding, but probably the greatest contribution it can make to science education on the elementary level is in developing appreciations, interests, and attitudes. That these are the major types of outcomes striven for in elementary science is re-

vealed by an analysis of eighty-nine courses of study made by the writers; yet these are the outcomes most difficult to measure.

Interest is the first prerequisite in effective learning, and many educators question the ability to learn when this element is lacking. Interest may readily be established at the outset by presenting a sound picture based on the unit of instruction as an introduction to the teaching unit.

It is our belief that sound pictures will stimulate the imagination, which may lead to a desire to investigate in greater detail the ideas that have been brought out by the picture and related problems. For richness in attainment, the pupils should pursue a diversity of activities.

In the past, the excursion has been looked upon as the prime device in nature study. The inadequacy and the impracticability of excursions are among the chief reasons that elementary science has, in many instances, failed to attain the objectives which have been set up for it. The excursion usually disrupts the school program, since much time is consumed in traveling to and from the sought-after setting in nature. In many large cities no suitable environment is accessible. At its best, only a superficial impression is usually attained on an excursion, although it does have an important value in facilitating the identification of flowers, trees, birds, and insects and in establishing the idea that the things the children have seen on the screen or have read about actually exist in their neighborhood. The secrets of nature are too subtle to be phantomed by a large noisy group in the time available on an excursion. Nature often seems averse to acting while she is being observed. Many processes take place only at night, while others have to be observed periodically over a number of weeks to be fully comprehended; but the sound picture can show these phenomena and processes of nature's actors. Some of these are remarkable; they seem almost unbelievable. With this background experience of the talking picture, the excursion and reading, the pupils may be led to appreciate the fact that these secrets are revealed if the observer will but practice patience. With this approach we can hope to instill that permanent interest which is one of the important objectives in elementary science.

Broadening the Scope of Science

It seems feasible, with the aid of the talking picture, that the extension of the course of study will include elements which are now omitted due to the difficulty of teaching them by means of traditional or present methods. This new medium makes possible that thorough integration of science which develops a full appreciation of its many interrelations. Without the talking motion picture attempts at integration partake too much

of the abstract, a condition which is entirely unsuited to the lower grade levels, and which ultimately reverts to the teaching of a few superficialities. Sound pictures will also make a distinct contribution to the enrichment of the curriculum, thereby giving an adequate background for the work to follow. The vividness of the medium and its ability to simplify difficult concepts and processes form a significant potential contribution in this direction.

To appreciate how the sound-motion picture will broaden the course of study, it is necessary to recognize the flexibility and versatility of this mechanical device. Telescopic photography makes possible the detailed study on the screen of objects that are beyond the range of human vision or that are otherwise inaccessible. Under this category falls the study of much of our wild animal life, the planets of the solar system, and some geological phenomena. At the other extreme is the technique of microphotography which makes possible the portrayals of the cellular structure of life, the flow of blood through the arteries, capillaries and veins of a frog's foot. Microphotography probably has its greatest value on the higher school levels.

Time-lapse and slow-motion photography are among the most important aids in portrayal of processes by actual photography. The former makes possible the presentation of action which is very slow. The winding of pea tendrils about a support can be shown in a few seconds, as can also the emergence of a butterfly from its chrysalis and the unfurling of its wings. Time-lapse photography may also be combined with microphotography to demonstrate the continuous development of the embryo within a frog's egg, the division of a one-celled organism, or the life and growth of a mold. Actual work with the microscope for elementary pupils is impractical because of the individual character of the work and the difficulty of obtaining suitable demonstration. Slow-motion portrays action whose speed defies the human eye and presents it in a manner that permits clear analysis.

Animation is one valuable technique which is peculiar to the motion picture. By this device it is possible to portray any process or structure which cannot be photographed. Relationships are thus easily presented. The internal processes of plant and animal life may be diagrammed in motion as well as complicated machines.

A further unique contribution of the talking picture is to be found in sound and speech. A narrative synchronized with the action on the screen aids in clarifying concepts. It increases the emotional response of the audience and the dramatic appeal of the picture. It also adds that intimate touch which was not found in the silent film and makes it possible for the

screen to portray related action continuously without the interruption of titles. Addition of pertinent natural sound produced by the object or subject on the screen contributes to the illusion of reality. Here may be included such sound as produced by waves, the wind, birds, people, and machines. Parts of the narrative may be so subtly phrased that it arouses a multitude of questions in the minds of the audience, thus stimulating the desire for further creative activities.

Extending the Teaching of Science

The failure of American schools adequately to teach science is due in part to inadequate training of the teachers. This situation is in direct contrast to that prevailing in Germany and England where science is an integral part of the curriculum. Normal schools and teachers colleges are now recognizing this deficiency and are requiring courses in this field.

The talking picture can make a definite contribution to the efficiency of teachers now in service, by supplying the science information which they have otherwise failed to secure in their pre-service training. The teacher can rest heavily on the "teaching" power of the film and devote her efforts to that of direction and stimulation. Such use of the talking pictures, however, does not bring out their greatest possibilities. With the aid of the unit of instruction which accompanies the truly educational classroom sound film, the teacher can make herself proficient both in the subject matter and in methods of teaching this content. It is to be hoped, however, that the teachers of the future will be properly prepared in this field while they are still in training.

Research studies which are being reported in increasing numbers will, in all probability, point out many other contributions and weigh them according to merit.

Equipping the Classroom for Sound Pictures

To take advantage of the Educational Talking Pictures which are available and are being prepared in increasing numbers, it will be necessary, of course, that the schools acquire suitable apparatus for reproducing these pictures. Auditorium installations will be desirable for the general school program, but the effective use of talking pictures in teaching requires presentations in the classroom. Past experiences with silent pictures have shown the practicability of the 16 mm. projector for this work and the question, therefore, is what type of 16 mm. sound equipment constitutes the best investment for the school system.

Most of the readers of SCIENCE EDUCATION are probably aware that

various manufacturers have made available 16 mm. equipments using sound-on-disc and sound-on-film. Between these, there is an assumption of technical superiority and ease of operation in favor of the sound-on-films. This arises from the feeling that the sound-on-film equipment has generally superseded the sound-on-disc in the theatre and from the fact that the sound-on-film contains both the sound and the picture on the same print, whereas sound-on-disc requires both the film and the disc. With respect to the first, the fact is that the sound-on-film method is in general

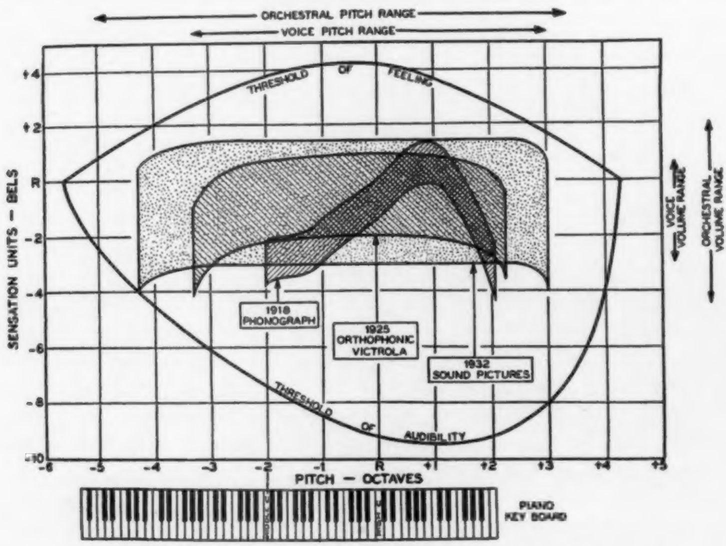

FIGURE 1. Range of Various Types of Sound Reproducing Equipment.

use in the theatre today not because of any technical superiority but because of commercial considerations of ease in shipping film programs quickly from town to town. In the school field this is not a factor since the school has its own pictures. Concerning the second point, ease of operation, the superiorities of the sound-on-disc method for classroom use are manifest. Essentially, such an equipment consists of a 16 mm. projector, with which most teachers are now familiar, and a turn-table geared to run with the projector. The start marks on film and record make synchronization easy and practical. The sound-on-film apparatus, on the other hand, requires the use of an exciting lamp, lens assembly, and photoelectric cell, which are delicate, difficult to keep in adjustment, and

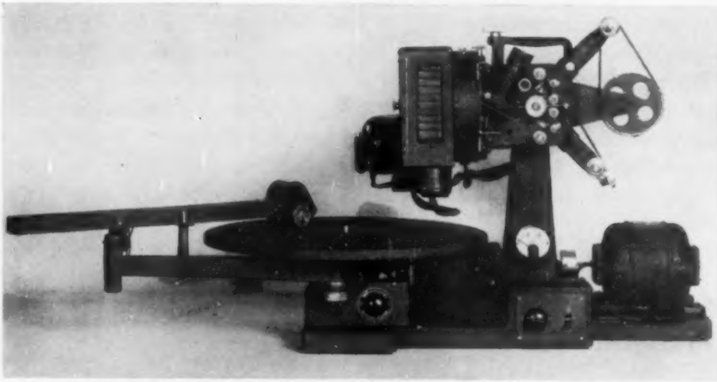

FIGURE 2. Close-up View of 16 mm. Sound-System Reproducer from Operating Side.

expensive to replace. Furthermore, the fact that the sound corresponding with a given frame is not associated with that frame but is printed on the film some four or five inches ahead of it makes the proper threading of the machine more difficult than operating a well constructed sound-on-disc apparatus. These considerations plainly dictate the sound-on-disc equipment for classroom conditions. There are technical reasons why 16 mm. sound-on-film cannot provide quality of sound equal to good theatrical reproduction—the decreased length of the sound track, the increased difficulty of guiding a narrower, lighter strip of film steadily past the sound aperture and other technical disadvantages which render inadvisable the sound-on-film method with 16 mm. film, even if the operating features such as the delicate light cell did not make such equipment undesirable for classroom use.

In purchasing sound-picture equipment for the classroom, one should be familiar with the characteristics of good equipment of the sound-on-disc type. The chart shows the range of sound which is necessary to quality of reproduction. It should be borne in mind that mere synchronization is readily obtained, while quality of sound can be secured only from equipment which embodies adequate technical knowledge and careful construction. There is available a 16 mm. sound-on-disc equipment manufactured by the Western Electric Company, which has installed the greater number of sound-picture equipments in the theatres. It may be worth while to consider the various features as a standard of comparison for this type of apparatus.

It is pointed out by the manufacturer that such an equipment should

embody the same principles which have been worked out for theatrical installations of sound-on-disc equipment. The construction should be such that the turn-table is kept free from vibration. Provision must also be made for the maintenance of steady speed of the turn-table without variation which would cause changes of pitch or "flutter" in the reproduced sound. In the equipment illustrated a single motor drives both the projector and the turn-table from a central shaft. The motor drive is mounted on a spring suspension which shields the balance of the equipment from the vibration of the motor. There is also a mechanical "filter" in the gear box below the turn-table which further smoothes out any unevenness of motion which might be transmitted to the turn-table.

An important feature of an equipment of this type is a motor which will run at a fixed speed. For this purpose, of course, where A.C. current is available an induction motor is much to be desired over the universal type of motor which is commonly used in 16 mm. motion picture projectors.

Another feature of this equipment which is pointed out as important is the arrangement of coupling the spring-suspended motor to the driving shaft with a clutch which permits the equipment to come up to speed with-

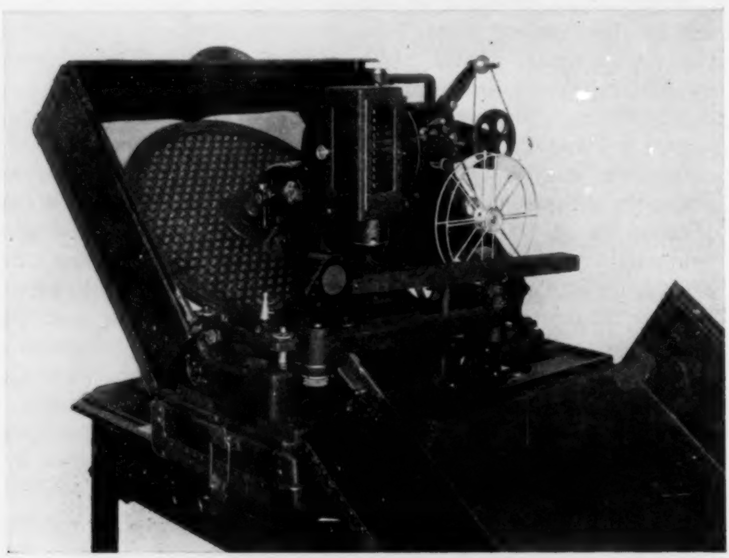

FIGURE 3. Showing Position of Reproducer Placed in Carrying Case.

out jerking the turn-table in such a way as to disturb the placing of the needle on the record.

The reproducer (corresponding to the phonograph sound head) used with the disc type of equipment governs more than any other single factor the quality of reproduction. The reproducer and reproducer arm used on the equipment illustrated is that used in the largest theatrical installations made by the Western Electric Company.

Questions arise about the difficulty of keeping film in synchronism with the discs when a break occurs. This difficulty is minimized by the use of a projector which safeguards the film such as the projector of the Victor type embodying automatic trip-devices for stopping the mechanism when too great pull is exerted on the film, and sprocket arrangement which will operate with a minimum of wear on the film. In the event that a film should be broken, it is a simple matter to replace any damaged frames in splicing it, so that the total length of the film remains the same. Such procedure involves only making two splices instead of one which, with a modern type of inexpensive splicer, such as the Griswold Splicer, can be readily accomplished in a few minutes even by inexperienced persons. In this connection it is interesting to know that Erpi Picture Consultants, Inc., offers to put back in synchronism any of its film which may have been put out of synchronism by a break. They point out that this requires a comparison of the footage with other prints of the same subject. Erpi Picture Consultants is a subsidiary of the Bell System which has already made more than fifty educational subjects, distributed both in the 35 mm. sound-on-film size and in the 16 mm. sound-on-disc size.

It is apparent that those who are engaged in the production of educational talking pictures are standardizing in the use of 16 mm. sound-on-disc for their classroom pictures. The University of Chicago has announced that its series of science pictures for high-school use will be issued in this form.

Developments such as the talking-picture program of the University of Chicago indicate the continued production of a supply of suitable subjects, which will make an investment in a really satisfactory equipment well worth while. As an easy test for judging the quality of such apparatus it is suggested that the prospective purchaser ask for demonstrations of pictures with music rather than with speech alone, since he will undoubtedly wish to use his equipment at some time for musical pictures. Another good standard of judgment of such equipment is the ruggedness of the construction and the indications given by its appearance of having been designed as a unit rather than being merely a collection of projector, turntable, reproducer, amplifier, etc., assembled from various sources.

"Genes"—the Units of Heredity*

Recently the interest of the scientific world was aroused by the announcement that Dr. John Belling, cytologist of Carnegie Institution of Washington, had actually seen the ultimate physical units of heredity in the cells of the lily, had counted and photographed them, and had observed somewhat of their behavior.

Until this announcement was made no one has ever thought that a *gene,* as the unit is called, had ever been seen. Like atoms, the existence of such entities has been inferred. A century ago, in attempting to explain the chemical behavior of substances, scientists found it necessary to assume the existence of atoms. All that has since been learned about the nature of matter seems well explained on the assumption that atoms exist.

So in biology, the results obtained from countless experiments in breeding plants, insects, and higher animals can best be explained by assuming that genes actually do exist, that they are located, as separable particles, at definite and constant places in the *chromosomes* (carriers of heredity), and that these genes are responsible for those hereditary traits which distinguish one species from another and one individual from another.

Heredity Versus Environment

Ever since Carnegie Institution of Washington was established, twenty-eight years ago, its Department of Genetics has had investigators at work in study of the rôles which heredity and environment play in the life of plants, insects, and higher animals, including man. As a result of their investigations and of those made by biologists working under the auspices of other agencies general agreement has been reached that every plant and animal is the product of two interacting influences.

One influence is the sum total of the internal factors that direct the development of the individual. This is heredity. The other influence is the sum of the environmental factors that determine the way in which the internal factors are able to express themselves in the development of the organism.

The actual appearance of an individual is the response of these internal factors to environment. Change in environment may modify the appearance of the individual to a greater or less degree; i.e., its sum total of inherited factors respond differently to the surroundings.

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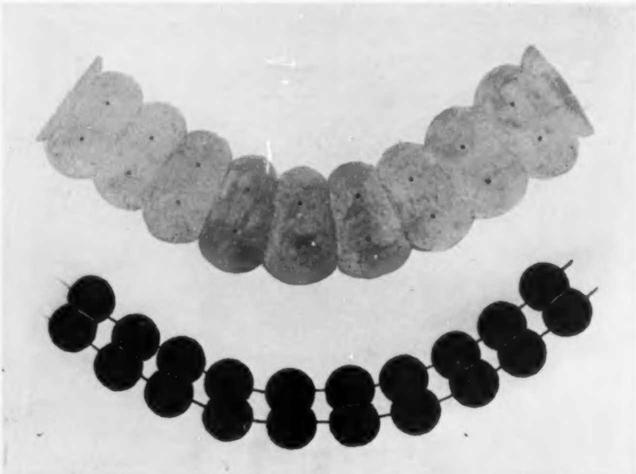
* Reprinted from News Service Bulletin, Carnegie Institution of Washington, Volume II, No. 31, May 8, 1932.

In speaking of these matters and of their implications Dr. C. B. Davenport, Director of the Institution's Department of Genetics, says:

"The thoughtful person can never cease to admire the wonderful way in which the world of natural objects is reproduced generation after generation. We wonder, on the one hand, at the great diversity of species; on the other, at the marvelous precision with which each species is repro-



Drawing by John Belling

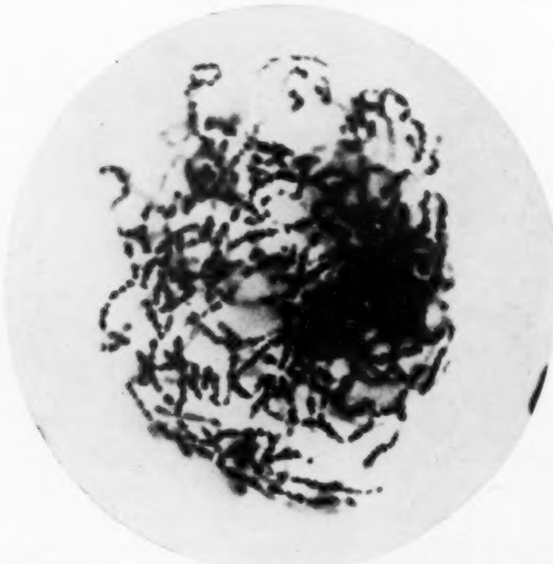
Upper—A double row of chromomeres in the pollen mother-cells of Allium (the onion family) as seen under the microscope, greatly enlarged. The chromomeres have been squeezed flat showing that there is an extremely minute gene in each. *Lower*—A drawing representing the above double string of deeply stained chromomeres before destaining and squeezing flat. The chromomeres in many plants and animals are so small that especially accurate microscopy is required to see them at all.

duced. We marvel, also, at the wonderful fitness of organisms to the world in which they develop and, in turn, reproduce.

"It is for the geneticist to give a scientific explanation of these phenomena, to bring under general laws the isolated facts of development, of diversity, of fitness.

"The first great advance in the scientific explanation of these phenomena was the tracing of the development of the individual by embryologists. The next was the discovery of the mechanism by which the internal factors that control development do their work. It is because the

germ plasm—the chromosomes and their constituent genes—shows a continuity that the species reproduces itself. It is the failure of the former germ plasm to continue to reproduce itself in the same old way that is responsible for genetic variation or mutation. Yet just that failure is regular; and the laws determining it are the subject of our investigation."



Photograph by John Belling

Photograph of chromomere strings in a single cell of the leopard lily.

Dr. Belling's Discovery

For a number of years Dr. Belling has devoted all his time to research on the mechanism of inheritance believed to lie within the microscopic bodies called *chromosomes* which occur in the nucleus of every living cell. His investigations have taken him into study of the principles of optics as they apply to extremely high-power microscopes, into search for plants having chromosomes which could be studied to best advantage, and into development of an improved technique in preparing chromosomes for observation.

He found that plants of the lily family were especially suited to his purpose because in them the essential structures are more widely separated

than in other plants. The Easter lily, the Madonna lily, the royal lily, and the leopard or tiger lily of California, were the members of this family which he most frequently examined; but it was in the last of these that he first observed the objects which he believes contain the genes.

Although, according to theory, genes are present in the tissue cells of plants and animals as well as in their germ cells; it is with the latter, more particularly the pollen mother-cells of the flower buds of the lily, that Dr. Belling works.

He takes the anthers (pollen-bearing flower parts) when they have

Drawing by John Belling

A somewhat diagrammatic camera drawing of one half of a chromomere string in the leopard lily.

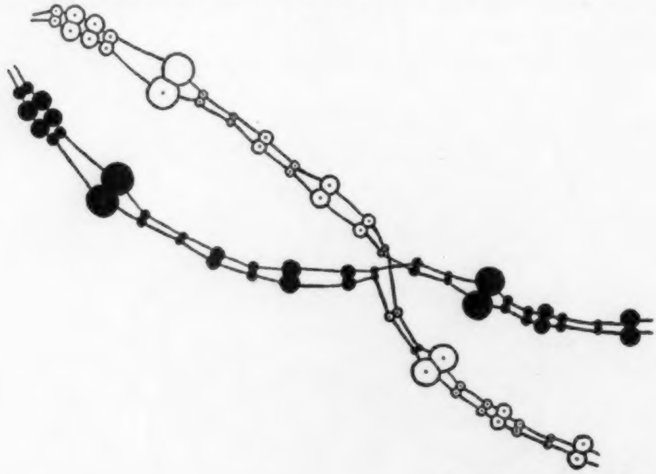
reached the proper stage of development, cuts them open and presses the mother-cells of the pollen out on to a clean glass slide which he instantly immerses in a fixing solution consisting of a combination of powerful chemical agents. It is important, he finds, that the cells be killed instantaneously; for if they are permitted to die slowly the structures which he wants to observe fuse and lose their distinctive appearance.

Having thus completed the preliminary preparation, he subjects the slides to treatment with various staining solutions which the cell structures absorb in differing degrees, thereby making them more easily distinguishable under the microscope.

So skillful in manipulating these diminutive pollen mother-cells has Dr. Belling become, and so successful has he been in finding dyes which

give maximum visibility, that even though the cells themselves are less than one four-hundredth of an inch in diameter, a size which is below the limit of unaided human vision, yet in these tiny containers he has seen and counted at least 2200 different bodies which he thinks are the ultimate units of the inheritance mechanism.

In the living plant, Dr. Belling states, a coat of stainable matter forms



Drawing by John Belling

Diagram, after a camera drawing, of the separation of a small part of the double chromomere strings in Fritillaria lanceolata, showing that the two parental chomomere strings (now both double) separate, at first in many places, leaving nodes between. In this case they have "crossed-over" (exchanged parts) at the node. Dr. Belling believes that junctions of the chromomeres at a bend, a cross, a twist, or an overlap in the chromomere threads account for the various phenomena connected with gene behavior observed by geneticists.

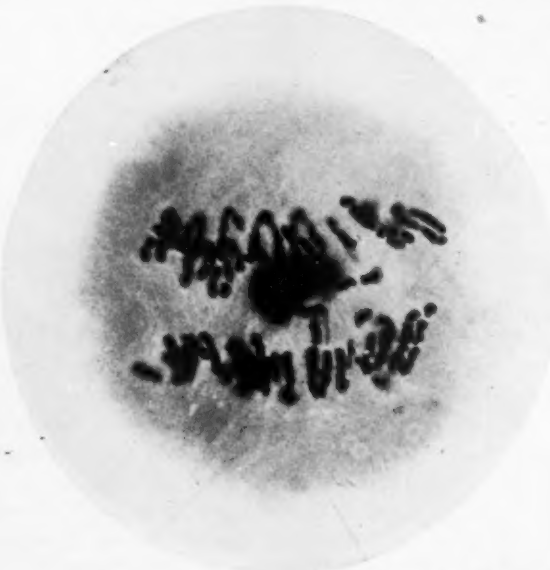
around the genes so thick and viscid that it can be pulled out into long strings. A gene with its coat of stainable matter is called a *chromomere.* Each of the strings of *chromomeres,* of which there are 24 in the tissue cells of the lily, constitutes a *chromosome.*

Dr. Belling has counted the *chromomeres* in the lily and showed that each contains a single core which is barely visible when conditions are most propitious; that these are plentiful enough to satisfy the theoretical requirements of gene numbers; and that the various phenomena connected with gene behavior, designated by geneticists as "crossing-over," "inversion," "translocation," "deletion," and "deficiency," can be accounted for

by junctions of the *chromomeres* at a bend, a cross, a twist, or an overlap in the chromatin threads.

Importance of the Gene

In commenting upon the function of these structures, Dr. Belling says: "A minute cell sphere with its 2200 gene pairs suggests the celestial



Photograph by John Belling

A photograph showing the complete separation of the split chromosomes of the twelve pairs from their mates in the lily. Another division follows, separating similarly the split halves. Then groups of twelve chromosomes are ready to pass as parent gene strings to new lily seeds. By the interchanges which have taken place, not only have the twelve chromomere strings of one parent been shuffled with the twelve strings of the other parent but a small amount of similar shuffling of the chromomeres has occurred.

sphere visible to the unaided eye and containing fewer than 3000 stars which can be seen at one time. These stars were supposed by some to exert a mystic influence on human beings. In the spherical cells of the organism, however, the genes actually do exert specific influences on the life of the organism in question, whether of the lily or of man. In fact these influences are so great that if the effects of all the thousands of genes in a

given organism were added together nearly the whole of its inheritance would be accounted for.

"These strings of chromomeres are of more consequence, therefore, than the threads of life, which, according to the old fable, the Fates were supposed to spin. Indeed, in many of the old sayings relating to the influences of the stars, if the term *gene* or *chromomere* be substituted for *star* the saying would hold today. Could we but identify every one of the *chromomeres* in a man (probably there are many more than in a lily), a reliable horoscope for him could be drawn up."

The relevancy of Dr. Belling's remarks concerning the influence of genes or chromomeres in heredity will become apparent when it is realized that the method by which the cells of plants and animals divide is such as to make certain that genes from both the parents are transmitted to the offspring. A quick review of the description which cytologists give of the basic features of the method will make this clear.

The Forming of Chromosomes

Nearly all living things begin with the fusing of two sex-cells, one from the male and the other from the female. This is fertilization, whereupon development begins. The single fertilized cell thus formed divides into two cells, these into four, the four into eight and so on until, in time, there are millions of cells organized, in the case of plants, into roots, stalks, leaves, flowers; and, in the case of animals, into bones, muscles, blood, heart, brain, and all the other tissues of the animal body.

In one respect the living cells, whether of plant or of animal, are all alike—they are filled with water and, moving through it, is a substance called *protoplasm* which holds suspended in it, usually in a central position, a spherical body of somewhat denser material called the *nucleus*. The nucleus is of great consequence, for it is known that it exercises a controlling influence on the physiological activity of the cell. It is also of particular importance in heredity.

When the cell is quiescent the nucleus apparently consists of a tangle of fibrous material. In preparation for cell division these threads appear to shorten and thicken, forming segments, twenty-four in the lily, forty-eight in man. These rod-like bodies in the nucleus, seen at this stage, are the chromosomes.

The Splitting of the Chromosomes

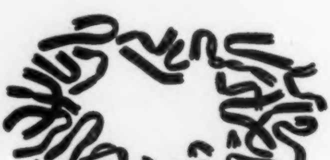
The chromosomes quickly take an orderly position at the middle of the cell whereupon fibers develop which connect each chromosome with opposite "poles" of the cell.

MAN *After Painter*

GRASSHOPPER *After Mann*

HOUSE FLY *After Metz*

HORSE *After Painter*



SALAMANDER *After Parmenter*

PLANT (Crepis) *After Mann*

Drawings of chromosomes of various organisms as seen under the microscope, greatly enlarged. Chromosomes are structures in the cells of living things which, through fertilization and cell division, pass from parents to offspring. Each consists of a great number of genes strung together in a single row like beads on a string. The development of the individual, it is thought, is brought about through the interaction of these genes. Each species of plant and animal has a constant and typical number of chromosomes: man and the monkey have 48; the frog 26; the pigeon, 16; the horse, 60; the fruit fly, 8; the house fly, 12; the lily, 24.

When this stage is reached each chromosome splits along its leng Thus two sets of chromosomes are formed, each set being a counterpai of the original set. The two sets then pass to opposite poles, drawn there, some think, by the contraction of the fibers, whereupon the cell divides. Two cells are thereby formed, each containing a set of chromosomes which is exactly like the set contained in the sister cell and both exactly like the parent set from which they sprang.

In these new cells each group of chromosomes takes a central posit and re-forms a spherical nucleus from which, after a resting period, chromosomes again emerge when these daughter cells, in their turn, are ready to divide. Through repetition of this process all the tissues of the individual plant or animal are built up of cells containing chromosomes which are all directly "descended" from those originally present in th fertilized egg.

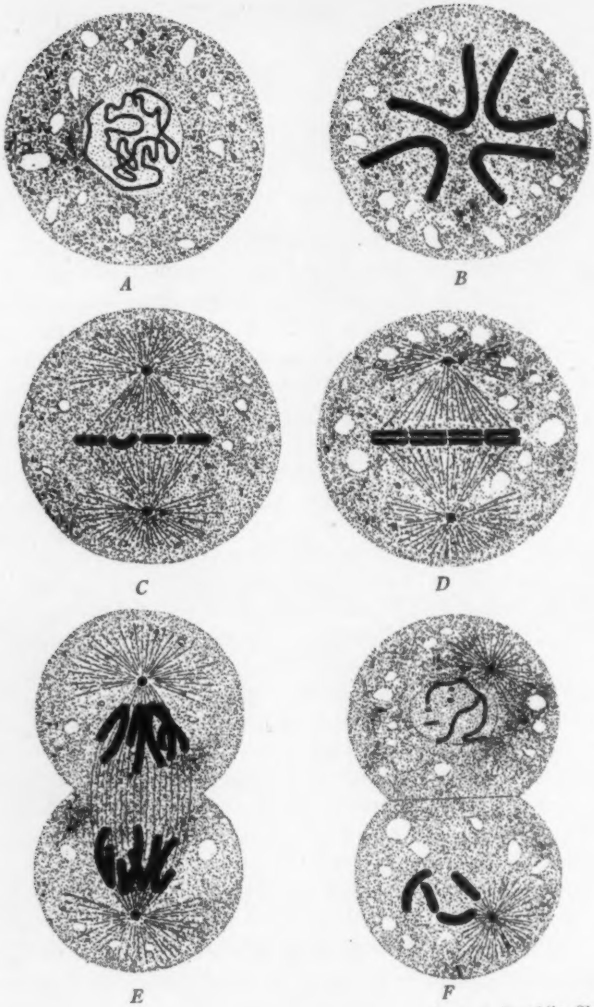
We have said that the process just described is such that a guarant is had that the cells of the individual plant or animal shall contain all th chromosomes characteristic of the species to which it belongs. This is true of all the cells of a given individual excepting only that group in each instance which is concerned with reproduction. By a striking modification of the process of cell division, the chromosome number in the germinal cells of both sexes is reduced to one-half the characteristic number.

Reduction Division in Germ Cells

The reason for this reduction in chromosome number is obvious. If there were no reduction, when the male and female cells unite the fertilized cell would contain double the characteristic number. In each subsequent generation the number would again double and so on indefinitely; thus a wholly absurd situation would soon arise.

As these germinal cells develop, the chromosomes in them come together in pairs while still very thin instead of splitting longitudinally and forming duplicate sets as they do in the ordinary tissue cells. The members of each pair, instead of the halves of each chromosome, separate to opposite poles, whereupon the cell divides into two cells. In this manner the number of the chromosomes is reduced to one-half, the full number being restored when fertilization takes place.

However, before the cells formed by this process of reduction mature and become capable of functioning in reproduction they undergo one further division which, it should be noted, does not change their chromosome number. That is to say, from any cell that undergoes this reduction division four cells are finally derived. In the male, whether of plants or of



After A. Franklin Shull

Showing the stages through which the chromosomes of Ascaris, a parasitic thread worm, pass when cell division takes place. Drawings of actual specimens cut in thin sections. *A*, early stage, chromatin thread slightly condensed; *B*, chromatin thread has formed into chromosomes which are arranged across the middle of the spindle; *C*, same as preceding, viewed from the side of the spindle, with chromosomes not completely in the section; *D*, chromosomes split lengthwise; *E*, chromosome halves moving apart, cell body beginning to divide; *F*, division of cell body complete, chromosomes in cell at top being reconstructed into a nucleus.

animals, all four become sperm cells capable of fertilizing the female. In the case of the female among animals only one of the four develops into an egg, the other three remaining functionless and clinging to the side of the egg in the form of small rudimentary cells known as "polar bodies."

Exceptions Noted

Although the foregoing steps in chromosome behavior are sufficiently general among plants and animals to justify the conclusion that they are typical, nevertheless, as investigation continues, significant modifications in the processes are found to exist. These relate particularly to the behavior of the so-called sex determining chromosomes. Moreover the work of Dr. C. W. Metz, of the Department of Genetics, on the fungus gnat, *Sciara,* shows that with this genus at least there are peculiarities in chromosome action which put it in a class apart and which open up problems the solution of which may throw much light on uncertain and little understood aspects of the inheritance mechanism.

For the general reader, however, the important things to remember about the basic features are these: that there is a method of cell division common to practically all plants and animals which insures that all the cells of the individual except the reproductive cells shall carry the full number of chromosomes characteristic of the species; that the reproductive cells in each case shall contain one-half of the characteristic number (except as modified in respect to the sex-producing chromosome); and that when the fusing of the male and the female cells takes place in fertilization the characteristic number is reëstablished.

The most striking feature of cell division, then, is the longitudinal bisecting of the gene strings (chromosomes) and the provision whereby every daughter cell is granted its full complement of these priceless genes, presence of which, according to all available knowledge, is essential to continuity of life, of organization and of species.

Study of the Fruit Fly

The work on the fruit fly *(Drosophila),* begun by Professor T. H. Morgan of Columbia University, and continued by him and his students, supplemented by investigations in other institutions, is chiefly responsible for establishing this gene theory of heredity. By breeding, literally, millions of pedigreed flies and observing the results, Morgan and his students have been able to identify the genes responsible for many of the characters which appeared in the adult flies and to prepare diagrams to show the locations of the controlling genes in their respective chromosomes.

At one time it was thought that for every character appearing in the

adult there is a gene to correspond: that, for example, there is a particular gene which controls wing shape; one which determines eye color; another which is responsible for head shape; and so on for all the other characters.

The work on the fruit fly, and that done in other investigations, however, proved this view to be untenable. It showed, for instance, that red eye color in this fly is the end product of the coöperative action of a troop of genes, of at least fifty in this case; that the wing of the fly is a complex requiring the interaction of hundreds of genes; and that all the other characters are responses in each instance to the influence of many genes.

In turn, each gene may affect many characters. Alter a single gene in a coöperative group and the character which is the result of the interaction of the members of that group will be altered. Thus a change in a single gene in the fruit fly may rob the eye of all color, giving a white eye, or it may change the typical shade of red to another slightly different. And what is true of the fruit fly in these matters applies equally well to all other organisms including man in so far as they have been studied.

Existence of Gene Confirmed

In the light of these considerations genes have been compared to discrete packets of different chemical substances (super-molecules perhaps) bound together loosely into chains. Each chain constitutes a separate chromosome made up of an enormous number of these packets of heredity, 2200 in all the chromosomes together, Belling says of the lily. Through the various processes taking place in the cell these packets are paired, distributed, and reassembled into new combinations, obeying, in so doing, certain definite laws of heredity.

It would seem therefore that explanation of the various ways in which the individuals of a given species develop, whether plant, insect, or man, of the peculiarities and diversities that give them individuality, and of the extraordinary resemblances and differences that exist between parent and offspring, requires the assumption that there actually exists a constituent physical entity in the chromosome which is passed along from generation to generation and that this is capable of bringing about the development in the new generation of the same character which its progenitors had developed in the parent generation.

Dr. Belling's announcement that he has seen this ultimate entity; that he has photographed it; and that he has watched its behavior in the several stages of cell division is another of the many striking instances in scientific investigation of how conclusions reached theoretically may later be confirmed by direct observation.

A Critical Summary of the Research on the Lecture-Demonstration Versus the Individual-Laboratory Method of Teaching High School Chemistry

DEWEY B. STUIT AND MAX D. ENGELHART
University of Illinois

Controlled experiments in education, in which attempts are made to determine the relative effects on achievement of different instructional procedures, are characterized by the application of these different procedures, for a period of time, to the pupils of equivalent groups. In the following paragraphs, the requirements, or specifications, for a precise experiment on the relative merits of the lecture-demonstration and the individual-laboratory methods of teaching chemistry, are described.

These specifications refer to techniques which appear to be most appropriate for use in attempting to solve this problem. They were adapted from specifications relative to experimental techniques given in the bulletin referred to below.[1] This description has two purposes: (1) to acquaint the reader with the writers' concept of what constitutes excellent experimental techniques, and (2) to set up a basis for evaluation of the reported experiments on this problem.

1. *Specification of experimental factors.*—The term lecture-demonstration is used to describe a method of teaching in which the teacher carries out a demonstration for the entire group and lectures in parallel with it. The students observe the demonstration and ask any questions which they desire about the demonstration or theory involved. In the individual-laboratory method each student performs every experiment. The instructor goes around asking questions about the work and the students also have the privilege of asking any questions about the laboratory technique and manipulation, or the theory underlying the experiments performed.

While the above methods are most commonly used, certain variations may be noted. In some schools the instructor asks questions in the demonstration method as well as the students. In others, the teacher asks no questions. In the laboratory method, experiments are sometimes performed by the group, or the pupils work in pairs or small groups, while in others they work individually. It is essential, therefore, in seeking to determine experimentally the relative influences of the lecture-demonstration and

the individual-laboratory methods on the achievement of chemistry students, that the instructional procedures compared should be specified in detail.

2. *Control of pupil factors.*—The groups of pupils used in the experiments should be equivalent in all respects that will affect their achievement in chemistry. Satisfactory equivalence may be secured by pairing pupils on the basis of measures of intelligence and then comparing them with respect to study habits, chronological age, and previous achievement in such school subjects as physics, general science, and mathematics. If the differences in means and measures of variability are small with respect to these characteristics, the groups may be considered equivalent. The experimental and control groups should be checked with respect to participation in extra-curricular activities. Excessive participation should not prevail in either group. The pupils of the two groups should not differ widely in home environments, in sex, in race, or in physical condition. It is probable that minor variations in these characteristics will offset each other. More than minor variations should be recognized in the qualifications made with respect to the conclusions.

3. *Control of teacher factors.*—An experiment in which two equivalent groups are taught by different instructors in the same school appears to be the best to the writers. In this way such non-experimental factors as size of school, school organization, administration and supervision, school building, and community attitude and interest are eliminated. Of course, the problem of the control of teacher factors still remains. This involves maintaining the same status of all the factors under this head in both the individual-laboratory and lecture-demonstration groups. Care should be taken that each teacher presents the same material to both groups; the only difference permitted being that of the method of presentation. Each teacher should be skillful in carrying out his particular method. The zeal and personality of the teachers should be as nearly equal as possible. In agreement with sound educational practice it seems advisable to select teachers for each particular method who have a preference for that method. The zeal exhibited by a teacher for a method should not, however, exceed that of teaching in the absence of an experiment. It should be an amount of zeal which can be maintained when the novelty of the method has ceased to engender enthusiasm for it. Such minor teacher factors as physical condition and age, usually need not be considered so long as extremes are avoided. It is advisable, however, to have teachers who have had about equal experience in the teaching of chemistry.

4. *Control of general school factors.*—The instructional materials

should be the same for the lecture-demonstration and individual-laboratory groups. The laboratory equipment used in demonstration by the teacher should not differ from that used by the individual pupils of the laboratory group. The textbook, supplementary reading materials and notebook requirements should be the same for both groups. The topics discussed in lecture and recitation should be the same for both and they should be given in the same sequence. It is advisable to have both groups take their work at the same time of the day in order to control the factor of fatigue. The knowledge of the fact that they are being experimented upon should be withheld from the pupils to avoid rivalry between the groups. The time devoted to learning activity should be the same in each case. The experimenter should endeavor to have an equal amount of time spent each day in learning activity, both in recitation and study, by both groups. The only difference in the instruction should be that in one group the teacher performs the experiments, while in the other group the same experiments are performed by the pupils.

In order that the instruction may be representative of sound educational practice the subject matter should be typical of that employed in chemistry courses of the better high schools of the country. The laboratory equipment should be complete in every way, but it should not be greatly superior or inferior to that typically used in the better schools. The control of non-experimental factors should not be so rigid as to prevent the teacher from adapting instruction to meet the needs of unexpected situations. For example, a pupil in one of the groups may ask a question which calls for information not included in the assigned subject matter. In the opinion of the writers the teacher should answer such questions and also take the initiative in having the information presented to the other group by their teacher. Failure to answer such questions, or to capitalize other unexpected opportunities for instruction, is not consistent with sound educational practice. It seems better to sacrifice something of precise control in order to secure teaching conditions representative of good educational practice. When good practice is sacrificed for the sake of precise control, application to future practice of the experimental conclusions is seldom justifiable.

The size of the class disappears as an educative factor in an experiment where equivalent groups are secured by pairing, since this procedure secures classes of equal size. If the groups are not equal in size, small differences do not appear to be significant, since within reasonable limits the size of class does not appear as an educative factor.

5. *Duration of experiment.*—In the opinion of the writers, the experiment should continue at least throughout one semester. If possible it should continue for an entire school year. A truly scientific experimenter would

be one who conducts several experiments on the problem over a period of years before publishing his results.

6. *Measurement of achievement.*—Equivalent forms of a chemistry achievement test of known and high reliability should be used as initial and final tests. When equivalent forms are used it is possible to compute mean gains. If the initial and final tests are not equivalent forms, the scores should be rendered comparable by the standard score technique, or some modification of it. Mean gains may then be computed for the distributions of individual gains in terms of standard scores. When this is not feasible comparison must be restricted to final test means. It should be noted, however, that where groups start with zero chemistry achievement, final test means represent mean gains.

When possible, additional tests should be administered to measure such outcomes as laboratory technique and manipulative skills, abiding interest in chemistry, and scientific attitude. After a period of several months (following the close of the experiment) a final test for permanent retention should be given. The relative retention value of the two methods can be estimated by comparing the results of this test with those of the tests given at the close of the experimental instruction. Superiority in the achievement of one group or the other, after several months, will constitute a strong argument for the method used with that group.

7. *Interpretation of experimental data.*—A difference in mean gains, or final test means, which is 2.78 or more times the standard error of the differences is customarily regarded as "statistically significant." It should be noted, however, that formulae commonly used in calculating the standard error allow only for variable errors of measurement and of sampling. Hence, a "statistically significant" difference may be undependable because of other limitations of the data, for example, systematic errors of measurement, validity, and sampling. The first of these types of errors is due to failure to control testing conditions, the second is due to failure to measure all outcomes, and the third is due to the selection of a non-representative sample of pupils with which to experiment. Failure to control important non-experimental factors may render a difference unreliable even though formulae show it to be statistically significant. In formulating conclusions the possibility of these limitations should be recognized and the conclusions qualified accordingly. Finally, it should be noted that while experiment may tell us which method is superior in engendering certain outcomes, which method *should be* used is in part a philosophical question. Its solution depends to some extent on the values we attach to the outcomes.

Description and evaluation of the experiments.—After measuring the

intelligence of his pupils by means of the Army Alphy Test, Form 9, and the Otis Group Test, Form B, Anibal[2] secured equivalent groups by a process of pairing pupils of equal or nearly equal intelligence. Two groups of 30 pupils each were used in the first experiment, and two groups of 17 pupils each were used in the second experiment. No doubt these groups were of satisfactory equivalence for, as Monroe and Engelhart[1,3] show, if pupils are equivalent with respect to mental age it is likely that they will be equivalent with respect to the other traits.

The school factors were rather carefully controlled. Instructional materials and time devoted to learning activity were nearly the same for both groups. Since the experiment was carried on in one school system such factors as size of school, school administration and so forth did not need to be considered. Teacher factors are hardly mentioned by Anibal. While instructional procedures were the compared factors and would have to be different in the two groups, the skill, zeal, and personality of the teacher should be held constant in a carefully controlled experiment. Objective tests constructed by the experimenter were used to measure achievement largely restricted to memorized information. The tests were so devised that guessing was reduced to a minimum. The final results show no great advantage for either method. As pointed out by Monroe and Engelhart[1] definite conclusions for either method cannot be made unless the differences in achievement are large.

In conclusion, the chief criticisms of this experiment would be these: (1) the groups were not very large, especially those of the second experiment; (2) one teacher was used to teach both methods; (3) the differences in gains were not large enough to arrive at any definite conclusions; (4) the tests used were neither highly reliable nor valid.

Nash and Phillips[4] in their experiment tested three methods: the pupil method, which corresponds very much to the project method; the combination method, which is much like the ordinary recitation and individual laboratory method; and the instructor method, which is commonly called the lecture-demonstration method.

Equivalence of groups was secured by selecting three groups of approximately equal mental age; hence they can be considered equivalent for experimental purposes in a general way. For an exact experiment more characteristics, such as previous achievement in chemistry, home conditions, study habits, and so on, should be considered. Only fifteen pupils were equated in each group. This appears to be a very small number upon which to base any definite conclusions. All three groups were taught by one of the writers.

The tests used were made by one of the writers from materials drawn from various sources. For more accurate and reliable results a test of known reliability would have been preferable. The results show quite an advantage for the instructor method over the pupil method, but the gain of the former over the combination method is very small. The large variability in the gains of the pupils who were instructed by the pupil method indicates that this method is probably suitable for only certain types of pupils. In the light of the evidence given it would be hard to base any conclusions on the relative value of the instructor method versus the combination method. The advantage of the instructor and combination methods over the pupil method is quite decisive.

The chief points of weakness in this study are: (1) the size of the groups was small; (2) there was no specific control of non-experimental factors, or at least not enough; (3) no tests of known reliability and high validity were used.

Undoubtedly the best and most dependable work on present laboratory practices has been done by Horton.[5] The first two experiments were conducted in order to set up a problem for the solution of which the last experiment was performed; that is, tentative conclusions and hypotheses were set up after the completion of the first two experiments which were verified by the third and final one.

In the first experiment, lasting one semester, four beginning classes were chosen as the experimental group and all the remaining classes made up the control group (having individual laboratory work). The groups were chosen at random but equivalence was checked by Regent's marks in biology. The non-experimental factors were carefully controlled. For example, as a result of supervision uniformity was maintained in sequence of topics, rate of progress, and assignment of lessons. The materials of instruction and time devoted to learning activity were carefully controlled for the two groups.

In addition to the use of the ordinary measuring instruments a very unique test was devised by Horton for the individual work in the laboratory. Horton here recognizes a principle that nearly all the other investigators have ignored, namely, that all the acquirements and achievements of laboratory work cannot be tested by the written examination. Hence an individual performance test was used to test these laboratory skills and manipulations. The findings of this preliminary experiment are decidedly favorable to the individual laboratory method, and particularly so with respect to laboratory skills.

The second experiment was rather short and consisted of a rotation

experiment. Only two experiments were performed by the groups. Class A had been instructed by the individual laboratory method and Class B by the demonstration method. Equivalence was again secured by Regent's biology scores, as was done in the first experiment. Each class was given an initial and final test in order to determine the difference in gains. Class A did one experiment by the individual laboratory method and one by the demonstration method. Class B did likewise; hence rotation was secured. The tests used were in the form of written quizzes. The results indicate an advantage for the group taught by the individual laboratory method in either case. No conclusive inferences could be derived from this experiment because the groups are small and the scope of experiment was not great enough. However, the results could be used for tentative conclusions or hypotheses, this being the capacity in which they are used by Horton.

In the third experiment an attempt was made at the verification of the tentative conclusions reached as a result of the first two experiments. Equivalence was secured on the basis of scores on the mid-term examinainations. This appears to be a satisfactory procedure, since previous achievement in a subject should be among the best criteria of future achievement.

The non-experimental factors were satisfactorily controlled. The teachers were chosen at random but the experimental classes were distributed among the seven teachers, so that each method was used by at least three different teachers. The instructional materials and time for learning activity were the same for both groups. The other school factors and extra-school factors were automatically taken care of, since the experiment was carried on in one school.

The tests used were reasonably satisfactory. The written test was shown to be highly reliable. As a supplement to the written examination a test of chemical judgment was devised. This attempted to measure the skill and judgment of the pupils in the laboratory. The third test employed was the individual performance test used to test laboratory procedures. This test concerned laboratory practices which everyone should know and hence should be of satisfactory validity.

The results show the individual laboratory method to be superior to the demonstration method in every instance, but not to any decided degree. A definite conclusion is hard to reach. It does appear, however, that the individual laboratory method teaches manipulations or skills which are not tested by the written test. This is something which has been overlooked by practically all the other experimenters. It appears justifiable to

include the laboratory skills and practices as part of the achievements that should be recognized in a course in chemistry.

This experiment is highly commendable in several respects. The groups may be considered to have been of satisfactory equivalence, the school factors were the same, the teacher factors were satisfactorily controlled and the tests used were reasonably reliable and valid. The groups were several in number, which is a definite aid in forming conclusions. Yet with all the definitely controlled conditions, Horton points out that the question of the individual laboratory method and demonstration method is still to some extent an unsolved problem. This study, as Horton says, is merely an inquiry into a great problem of which the problem of this experiment is only a part.

Wiley[6] experimented on the relative values of what he calls the textbook method, lecture method, and laboratory method of teaching high school chemistry. Equivalence was based on physics grades. The size of groups was small, each of the groups containing but eight pupils.

The tests used were in the form of résumés written by the pupils. A certain number of ideas were decided upon as being important in the judgment of the investigator. This does not seem to be a very satisfactory method of testing. The teacher factors are not mentioned by the writer, nor are any of the other non-experimental factors. The school factors and extra-school factors were controlled, since the experiment was performed in one school.

In the judgment of the writers the experiment is not dependable because: (1) equivalence was not very carefully considered; (2) the groups were small; (3) the tests used were not highly reliable or valid; (4) non-experimental factors were not satisfactorily controlled; (5) the results are not conclusive because the differences in achievement were not consistently favorable to any one of the three methods.

The experiment of Knox[7] concerns only the relative merits of the lecture-demonstration and individual laboratory methods. He carefully defines exactly what he means by each method. Fairly large groups were used for the experiment (forty-three in the two laboratory groups and forty-two in the two demonstration groups) and equivalence of groups was taken care of by the Miller Mental Ability Test. The non-experimental factors were rather carefully controlled. It would possibly have been better to have had one teacher instruct both demonstration groups and the other both laboratory groups.

The tests employed were made by the author and were not of known reliability. The scoring, however, was very carefully done and the results

were expressed as sigma scores. The results show the laboratory method to be superior for the inferior pupil and the demonstration method to be superior for the better students. This outcome agrees pretty well with those of most other experiments as regards dull and bright pupils. On the whole the experiment seems to have been rather well controlled but the results are not very decisive and hence no definite conclusions can be formed.

Pugh[8] experimented to determine if the lecture-demonstration is as effective as individual laboratory work. No attempt was made to obtain equivalent groups with respect to size and mental ability. The average intelligence of each section was determined after the results were obtained. Eighteen tests were given but they were not of known reliability or validity. The differences in gain are not large but they are consistent in showing the demonstration method to be superior in both the immediate and delayed retention tests. The non-experimental factors are hardly mentioned by the author. The teacher factors should certainly not have been overlooked. The school factors did not require attention, since all the pupils attended the same school.

The writers believe the following points should have been more carefully considered: (1) groups of equal size and mental ability should be formed at the beginning of the experiment in order that the pupils could be paired for scoring purposes; (2) the non-experimental factors should have received more attention; (3) the tests are not of known reliability or validity; (4) the results are not conclusive for, although the differences are consistently in favor of the demonstration group, they are small.

The experiment by Carpenter[9] involved the use of a larger number of pupils than any other thus far conducted. Classes in twenty-three schools in fourteen states participated in the study. The methods studied were the demonstration, individual, group-of-two, and the control method in which the student took an examination before performing the experiment.

At attempt was made to secure equivalence of pupil characteristics by the utilization of a rotation technique. This procedure seems less desirable than that of equating groups with respect to measures of intelligence and of checking equivalence with respect to other traits. When rotation is used there is always the possibility of carry-over from one method to another of habits of learning, or study, engendered by one method but not the other. Certainly, the fact that all of the pupils had some laboratory experience should produce a different type of response to the demonstration instruction, than would have been the case had rotation not been resorted to. The control of non-experimental factors is not mentioned by the writer.

Since the experiments were conducted in a number of different schools, it is possible that some of the limitations of the data of the individual schools were offset when the data were combined.

The tests used were of the objective type, but of unknown reliability. Specific information and ability to think in terms of chemistry were measured. No tests were given for laboratory technique and manipulation, scientific attitude and lasting interest in science. It seems advisable to test at least the laboratory skills and manipulations and to use a standardized test for a proper evaluation of a student's knowledge of chemistry. The experiment was of fairly long duration. It is excellent from the standpoint of representativeness of pupils, schools, and teachers. The handling and interpretation of the data are also commendable. The conclusions state that for the majority of high school pupils where achievement is measured in terms of specific information and ability to think in terms of chemistry the pupils succeed equally well with either demonstration or individual laboratory work. Pupils work better in the laboratory when they work individually. Carpenter concludes that demonstration is preferable for the duller pupils.

A Summary of Conclusions

In comparing the experimental evaluations of the methods of teaching high school chemistry one is impressed by the variability of conclusions reported by the various investigators and the general inadequacy of the experimental techniques. It is evident that all the valuable outcomes of any one method are not tested by all the investigators. Much of the data seems unreliable and invalid due to lack of validity and reliability of tests, doubtful control of teaching conditions and the use of small, unrepresentative groups. Few writers base their conclusions on more than one trial. This hardly appears justifiable, for in any science, results require reëxamination before they can be assumed to be dependable. In hardly any case is the method used by one instructor exactly like that used by another. There is no standard demonstration or laboratory method. However, in order to arrive at a few general conclusions it seems advisable to draw up a summary of the conclusions made by the various investigators; of these, the following are some of the more outstanding:

I. *Conclusions contending that the laboratory method is superior.*

1. There is a slight indication that material was better retained when taught by the individual laboratory methods (Anibal).

2. The order of preference of the methods studied places the individual laboratory method before the demonstration method (Horton).

3. In every respect the lecture method is *least* effective in imparting knowledge to high school students (Wiley).

4. For permanent learning the laboratory method is perhaps slightly superior (Wiley).

5. For providing knowledge and method of attack, the laboratory method is superior for the inferior pupil (Knox).

II. *Conclusions claiming that the demonstration method is superior.*

1. Bright pupils are more likely to profit by the lecture-demonstration method than are the others (Anibal).

2. Dull pupils profit more from demonstration than from individual laboratory work (Carpenter).

3. The lecture demonstration takes less time and costs less (Anibal).

4. The teacher (demonstration) method is best (Nash and Phillips).

5. Lecture-demonstration method gives better control over the individual since all are under teacher guidance (Pugh).

6. For purpose of providing knowledge for both immediate and permanent retention and for the purpose of providing technique for handling new problems, the demonstration method is much to be preferred to the laboratory method in case of average superior pupil (Knox).

III. *Conclusions contending that the students achieved equally well by either method.*

1. Immediate retention is about equal in both lecture-demonstration and individual-laboratory methods (Anibal).

2. There is not as great a difference as is ordinarily supposed in the value of the three methods, lecture, textbook- and laboratory, so far as imparting knowledge is concerned (Wiley).

3. The results of this experiment point to the conclusion that the majority of students in high-school, laboratory-chemistry classes, taught by the demonstration method, succeed as well as when they perform the experiment individually, if success is measured by instruments which measure the same abilities as are measured by these tests, namely, specific information and ability to think in terms of chemistry (Carpenter).

IV. *General conclusions based on evaluation of the reported research.*

After considering the above conclusions the writers have arrived at a few ideas which seem justifiable in the light of the evidence given by this study.

1. No method can be considered to be the best in every case. The objectives of chemistry teaching, the preference of the teacher, the nature of

the pupil, and the facilities of the school will largely determine which method should be used.

2. In small schools where money and space are not plentiful the lecture-demonstration method seems to be most practicable.

3. The written test cannot be used to test all the outcomes of a course in high school chemistry. Some sort of manipulative tests seem necessary to test the laboratory skills.

4. The problem of the relative merits of the lecture-demonstration and individual-laboratory methods still seems unsolved and as complex as ever. More careful experimentation, involving careful control of non-experimental factors and reliable testing, is needed in order to justify any definite and final conclusions. When experimentation has shown the relative superiorities of the methods in terms of outcomes, the methods should be evaluated in terms of the values attached to these outcomes.

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An Attempt to Vitalize Chemistry Teaching in the High School Through a Modified Form of the Unit-Assignment Technique*

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Application of the Unit Technique and Experimental Results of its Use

The technique here employed may be thought of as involving four stages: (1) presentation, (2) study period, (3) organization, and (4) evaluation.

To avoid the appearance of formalism, may it be understood that no rigid line of demarcation is implied by this classification. In the discussion to follow, there will be revealed a constant overlapping of function. While presenting the unit, there will be learning. During the organization period, the learning function will again appear on the highest order. The functions of evaluation and organization will likewise permeate every stage of the process. It is merely to serve as points of emphasis that these stages find justification. Any other point of view would tend to reduce the technique to the state of formalism, that has proved the fate of many well-conceived devices in education.

Presentation.—The most critical stage of the whole procedure is in the presentation of the unit to the class. This is distinctly the teacher's part. It is the golden opportunity to orient and motivate the class in the unit; that the class may start with a sufficiently well-integrated notion of where the unit will lead and some notion of the way, and above all, an appreciation of the worthwhileness of the whole endeavor. This must all be done without robbing the unit of its challenge. At this stage, there is much of the air of starting anew. There is much of that initial interest and spontaneity in anticipation of a new venture. This furnishes the point of departure. It must be maintained and accentuated as the presentation progresses.

The presentation, as a rule, will require, at least a full class period. If the subject is metals, have on display on the table, a large number of metals and associated materials. Then proceed with the preview talk. This

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talk should embody the most interesting general implications of metals possible to muster, and always connect, at every possible point, with the interests and experimental background of the class. The talk should call forth many experiences and impressions from members of the class. The teacher should be so full of his subject as to reflect enthusiasm for it, and the whole procedure should breathe an air of intimacy between teacher and class. If successful, the class should be engrossed with a desire to proceed with the study, in a spirit of adventure, to know more about the nature and significance of these interesting materials.

When this has been accomplished, the study plan is distributed. The teacher will follow through the problems and note, in a general way, the nature of the steps by which the study will proceed, problem by problem. Considerable time will be spent in a quite detailed survey of the list of special problems, to see just what they offer; to note their bearing on the unit; and to discuss sources of help and ways of getting at them. If it is a question of chemistry poems, take time to read some to show the possibilities in such a project. Read some chemistry dialogues and plays. Show the possibilities the unit offers for exhibits, posters, scrapbooks, graphs, slogans, entertainments, models, etc. With this part of the presentation a degree of levity can be introduced with profit.

Study Period.—During this period, the major emphasis centers on the learning function. For the accompanying unit on metals, it would require, at least, three weeks. The pupils arrive in the class-room with their procedure planned for the period. If they wish to do the reading as related to the problem, they will requisition by slip the necessary references and take reading notes. If it is a laboratory exercise, they proceed directly to that and take notes as to the bearing of their findings on the problem. If it is a demonstration requiring attention of the entire class, the instructor will arrange for volunteer members to perfect the technique and carry it out for the class. At this time, the instructor will take advantage of the opportunity for group discussion on the progress of the work. These occasional summaries, afforded by such opportunities, avoid the administrative difficulties inherent in the more completely individualized methods. The members will gradually come to realize that it is to their advantage not to proceed too far ahead of the general progress of the class and will divert their efforts for a time to other phases of the work, as extra projects, extra reading, and phases of the report.

After proceeding in this way, problem by problem, until the scope of the unit has been completed, the members of the class will have achieved a vast body of facts, impressions, and experience in the subject of the

unit. Some will, by aid of the occasional discussions and self-testing exercises along the way, succeed in making a fairly adequate tying-up of the experiences into an ever-enlarging conception, but with many, the knowledges will still be fragmentary and the organization inadequate.

Organization Period.—Then comes the period of summarizing and organization. After all the activities of the unit have been completed and a great body of impressions, knowledges, and experiences in the realm of the unit have been achieved, it becomes the purpose of this period to tie them all up in a large integrated whole. The end products of learning are here sought: those concepts, ideas, understandings and appreciations, that should remain after much that has been learned is forgotten.

This is the most inspiring stage for the teacher and most stimulating one to the class. It is best accomplished by selecting members of the class who are most able in organizing their experience and presenting ideas. Let these be responsible for presenting from notes an oral summary of the achievements of the unit, subject to criticism by the class. The class is full of the subject and keen in criticism. This stage can usually proceed for, at least, two days without lag. The teacher should be alert and terminate this stage short of a lapse of interest.

Following the summary, about two days will be used in the process of evaluation. One period will be needed for the test, and the other for receiving and checking work and disposing of numerous odds and ends attendant upon the closing of a unit of work.

Credit may be earned in a number of ways. All must pass the unit test at a fixed minimum grade. Failure in this involves the necessity of more work and a retest in the unit until such grade is achieved. The remaining points may be achieved in a variety of ways. All are encouraged to write a report on the unit, to be graded on the degree to which it shows organized understanding of the field. A large majority of the class will submit such reports in completion of the unit requirement. Most of these reports will show growing improvement in ability to organize the body of experiences and knowledges of the unit into a significant unified tie-up. Some choose to supplement both test and report by one or more of the optional projects. (See SCIENCE EDUCATION, February, 1932, p. 218-219). It is significant to note, however, that those of higher academic capacity show but little interest in the projects. It seems to be more congenial to their interests and tastes to rely upon the more distinctly academic requirement as implied by test and report. The less able student who can do no more than a minimum test grade, and that often by strenuous and repeated effort, will do several of these jobs in a most admirable way, and

submit them, flushed with a high sense of achievement. These students, if forced to compete on the same level with the former group, would probably have failed miserably.

On this last day for closing the unit, each student is required to submit to the teacher a form bearing a list of all work completed for the unit. This is the student's claim to the teacher for credit. This reverses the old order. Instead of the teacher telling the student, at this stage, what he should have done and why he failed, the student presents his claim to the teacher in a positive way and backed up with tangible evidence of achievement. The detailed and accumulative record of the class is kept regularly posted for the student's information.

There is no drive nor urge from the teacher at any point. As the unit is approaching completion, a tentative time is set for its termination. This is to serve merely as a warning, not as a threat.

The Experiment for Comparative Mastery and Retention

The Experimental Conditions

The achievement of the chemistry classes of 1930 was compared with the achievement of similar classes of the previous year. In 1929 the classes hereafter referred to as Group A, were taught by the daily-assignment method. The following year the classes, later called Group B, were taught by the unit-assignment method. In every other respect the conditions of instruction were identical:

1. The pupils were from the same community.
2. Classes were of the same size, twenty-four pupils each.
3. They were taught in the same laboratory.
4. Classes came at the same periods of the day each year.
5. Periods were of the same length.
6. The same instructor taught them.
7. The same test was used for both groups throughout all stages of the experiment.

By utilizing the groups of consecutive years for the experiment instead of equivalent groups of the same year, several significant irrelevant factors were eliminated as follows:

1. With the first group, the instructor had no thought of any method but the old type daily-assignment method. He had, as a result of ten years' experience, developed an appreciable degree of skill in its use and was achieving, by it, everything within his ability. So the record would stand as a closed verdict on that method.
2. With the following year's classes, the instructor entered upon the unit assignment method with all the zeal and skill he could muster. In spite of any enthusiasm he may have acquired for the latter method, none of its effect could be transferred to the first test group, as might have been the case if the experimental groups had been running at the same time.

3. The separation of the experimental groups by a period of a year, eliminated all possibility of transfer of enthusiasm and instructional aid from one experimental group to the other.

To determine the relative effectiveness of the two methods in teaching the subject-matter of chemistry, it was only necessary to compare the final test scores of the two groups. To determine the relative degree of retention of the two groups, a retest was given to each group, respectively, about one year after having completed the study of chemistry. The difference in score between the original test and the retest constitutes a measure of retention for the respective groups. These two measures, in turn, afford a basis for judging the relative effectiveness of the two methods for retention of subject-matter learned.

Method of Equating Groups

The two groups, as a whole, could have been considered fairly well equated on the basis of chance and similarity of experimental conditions. To insure a more refined equality, however, individuals were matched on the basis of age, grade, sex, intelligence record, and scholarship achievement. This furnished two equated groups of thirty each, out of their respective enrollments of about ninety.

TABLE I
COMPARISON OF EQUIVALENCY MEASURES FOR GROUPS A AND B

Equating factors		Group A	Group B
Age	Mean	17.3	16.6
Sex	Male	24	24
	Female	6	6
Grade	Mean	11.3	11.5
	Median	11	12
I. Q.	Mean	110	109.7
	Median	110	110
	Deviation	7	7.5
Scholarship	Mean	76	75
	Median	73	75
	Deviation	4.2	4

TABLE II
COMPARATIVE MASTERY FOR GROUPS A AND B FOR EACH PART OF THE TEST AND FOR THE COMPLETE TEST AS INDICATED BY MEAN, MEDIAN, AND QUARTILE DEVIATION

Parts of Test		Group A	Group B	Rating of B with A
1. True False. Reasoning and Memory.	Mean	23.6	20.1	−3.5
	Median	24	20	
	Deviation	10	8	2.0
2. Completion type. Memory of facts.	Mean	17	14	−3
	Median	17	15	
	Deviation	2	2.7	−0.7
3. Common and chemical names. Memory.	Mean	15	10.2	−4.8
	Median	15	11	
	Deviation	4.2	3	1.2
4. Problems. Skill in formal application.	Mean	12.2	11	−1.2
	Median	10	11	
	Deviation	5	10	−5.0
5. Commercial Processes. Practical application.	Mean	22	26	4
	Median	20.5	25	
	Deviation	7	2.7	4.3
6. Equations. Formal application of principles.	Mean	16.4	14	−1.6
	Median	15	15	
	Deviation	7.5	7.5	0.0
7. Composition. "Chemistry and the Home."	Mean	10.5	15.5	5
	Median	10	15	
	Deviation	3.7	3.7	0.0
Test Score.	Mean	116	112	−4
	Median	117	106	
	Deviation	27.2	21.7	5.5

Table I shows the two experimental groups equated on the basis of age, sex, year, intelligence quotient, and scholarship. The I.Q. is based on the Terman Test. Scholarship rating is based on the final mark for all work of grades IX, X, XI. The rating for each student was computed on a quality point basis in the following manner: the year grade in each subject was multiplied by its academic point weighting, e.g., algebra 80 per cent, 5 points yields 400 quality points; mechanical drawing 90 per cent, 1 point yields 90 quality points. These were totaled for the three years and divided by the number of academic points to secure the scholarship rating. This method furnishes a means of evaluating scholarship achievement in the heavy academic studies and the lighter manual arts and fine arts activities on an equivalent basis.

The Test and Results

The test consisted of seven parts as indicated by Table II. Part one was a group of sixty-two true-false statements of the multiple type. They involved some degree of reasoning, but the major emphasis was on the side of memory. Part two was a list of twenty-five incomplete statements accompanied by a list of thirty terms from which to select the correct term to complete the statement. This was essentially a combination of the matching and completion type. It placed special emphasis on memory of facts. Part three was a matching exercise of twenty-five chemical and common names. This was almost a pure memory test. Part four consisted of two problems, one of the percentage composition type and one of the reaction type. The latter was accompanied by the complete equation. This part of the test may be regarded as a measure of skill in formal application of principle. Part five related to commercial processes. Labelled drawings illustrating the process, accompanied a series of questions about the process that could be answered by a single word or short statement. The questions were designed to test a fairly comprehensive understanding of the process, rather than factual knowledge. Part six gave, in words, the reacting members of five equations, each typifying one of the standard types of reaction. The student was to write and balance the equation. This was a test of knowledge of types of reaction and technique of writing equations. This could be regarded as formal application of principle. The seventh part called for an essay of three to five hundred words on "The Benefits of Chemistry to the Home." To summarize:

1. All but twelve per cent of the test was objective in nature. Part seven was the only distinctly non-objective phase.
2. Parts one, two, three, comprising fifty per cent of the test, were almost entirely factual memory items.

3. Parts four and six, comprising about thirty per cent, tested skill in formal technique of solving problems and writing equations. This called for an element of reasoning involved in the manipulation of principles.
4. Parts five and seven, scarcely less than twenty per cent, tested understanding and appreciation of chemistry as applied in the home and industry.

Results of Test

Table II shows the mean, median, and quartile deviation for each part of the test. These values are paralleled for Groups A and B. The column at the extreme right shows the comparative rating of Group B with Group A, as indicated by the mean and the quartile deviation. The difference in mean for the two groups is shown. When this value for Group B was less than for Group A, the difference was indicated as a negative quantity for Group B. When the value for Group B exceeded that for Group A, the difference was stated as a positive value for Group B. The same procedure was followed for the deviation measure, except that the smaller deviation was indicated as a positive value when it was in favor of Group B.

It will be noted that the central tendency for Group B is slightly lower for parts one, two, three, four, and six. These parts called for a minimum amount of thinking in terms of concepts of chemistry. The emphasis was especially on memory of facts and mechanical application of principles in the solution of arithmetical problems and equation writing. This shows the result of formal classroom drill on these mechanical processes as practiced systematically under the daily-assignment method, in contrast with the incidental nature of this formal work under the unit-assignment method.

On the other hand, the central tendencies of parts five and seven, reveal a substantial gain for Group B. This would seem to indicate a greater wealth of ideas and understandings as related to the practical phases of chemistry. This might be expected from the much greater volume of reading and project experiences encouraged by the unit method.

Considering the test as a whole, the final score shows a slight gain in favor of the daily-assignment method. This includes all parts of the examination and needs no further interpretation.

The deviation values in Table II constitute a measure of uniformity of achievement by the members of the respective groups. The more concentrated grouping around the central tendency could be interpreted as evidencing more adequate provision for individual abilities. The result for parts one, two, three, and five, reveal a considerable advantage in favor of the unit plan. This should be expected, as a result of the flexibility of the unit assignment in providing different types of learning activity and freedom to distribute study time. In part four, the gain swings noticeably

to the old method, and in part six, both are equal. This would again show the effect of emphasis of the old method on classroom drill on these formal parts. The equality of distribution in part seven does not readily lend itself to interpretation.

In the final test score, the same results follow, and should need no further interpretation.

Comparison of Relative Retention

As a result of losses through graduation and other causes, the originally equated groups were so disrupted that it was necessary to equate again. This time the basis of equating was limited to the intelligence quotient

TABLE III
COMPARISON OF EQUIVALENCY MEASURES FOR GROUPS C AND D

Equating factors		Group C	Group D
I. Q.	Mean	112	112
	Median	114	113
	Deviation	9	9
Scholarship	Mean	76	76
	Median	74	77
	Deviation	4.5	4

and scholarship standing. The other factors, age, sex, and grade, were ignored for two reasons: first, that they would have but little, if any, bearing on this part of the problem, and secondly, that they would restrict the selection of matched subjects, in view of the reduced enrollments, to groups too small for valid comparison. Twenty subjects from each of the two enrollments were matched. The group instructed under the daily assignment plan will be designated as Group C and that under the unit plan as Group D.

The close equivalency of the two groups will be apparent from Table III. This shows the equivalency measures paralleled and so nearly equivalent that any discrepancies are too minor to warrant comment.

The pupils, about fifty each year, were assembled for the retest with no previous knowledge of what was to be asked. The reasons for asking them to repeat the test of a year previous were then fully explained. Time was taken to turn through the test, page by page, to note the directions

TABLE IV

RELATIVE RETENTION OF GROUPS C AND D FOR EACH PART OF THE TEST AND FOR COMPLETE TEST SCORE

Parts of Test		Group C	Group D	
1. True False. Reasoning and Memory.	Original	510	480	
	Final	430	387	−3%
	Retention	84%	81%	
2. Completion Type. Memory of facts.	Original	337	326	
	Final	259	255	1%
	Retention	77%	78%	
3. Common and chemical names. Memory.	Original	316	261	
	Final	166	173	14%
	Retention	52%	66%	
4. Problems. Skill in formal application.	Original	240	300	
	Final	100	135	3%
	Retention	42%	45%	
5. Commercial Processes. Practical application.	Original	467	531	
	Final	310	425	14%
	Retention	66%	80%	
6. Equations. Formal application of principles.	Original	340	330	
	Final	171	215	15%
	Retention	50%	65%	
Total	Original	2210	2228	
	Final	1436	1590	6%
	Retention	65%	71%	

of each part and the basis for rating each. This was done merely to relieve the sense of mental shock and confusion that accompanies the sudden appearance of such an uncongenial task and to get the group into a more receptive attitude of mind. Their sincere effort and coöperation was

solicited as an invaluable part of the endeavor. All parts were answered on the retest, except the essay question, part seven. This was omitted, since its lack of objectivity would make it unreliable as a measure of retention.

Table IV shows the comparative results of the two methods. The sum of the scores of each experimental group is shown for each of the six parts of the test and also for the complete test. These totals for the original and the retest constitute a measure of retention for the respective groups. This is stated on a per cent basis. The difference between these percentages for Groups C and D furnishes a measure of comparative retention for the two groups, and consequently, furnishes a measure of the relative effectiveness of the two methods of instruction for retention of subject matter learned. The last column of Table V shows these measures.

In the parts of the test where Group C shows the higher percentage retention, the difference is represented as a negative value for the unit method. When the reverse is true, the difference is recorded as a positive value for the unit method.

Part 1 shows the advantages of three per cent in favor of the daily assignment method. The remaining five parts show an advantage in favor of the unit method, ranging from one to fifteen per cent. The total results show six per cent greater retention under the unit plan than under the daily assignment method.

Conclusions

It is obvious that the findings of no single experiment may be regarded as final and conclusive, but merely as indicative of a probable trend, pointing to more valid, ultimate conclusions. It is in keeping with such a view that the results of the experiment seem to warrant the following conclusions:

1. The unit assignment method is slightly less effective than the daily assignment method in teaching those parts of chemistry that call for factual memory.
2. The unit assignment method is practically equal to the daily assignment method in those parts of chemistry that involve mechanical application of principle.
3. The unit method is considerably superior to the daily assignment method in those parts that involve practical application and appreciation of chemistry in its relation to industry and to the home and life.
4. The unit method possesses an appreciable superiority over the daily assignment method in providing for individual differences as indicated by the more uniform performance of all members of the class.
5. Chemistry subject matter, learned under the unit assignment method, will be retained more effectively than that learned under the daily assignment method.

In general, according to this experiment, it can be concluded that students will acquire knowledge of formal subject matter of chemistry more effectively for temporary retention when instructed under the daily

assignment method but will retain subject matter better, when learned under the unit method.

In addition to the foregoing objective findings, the instructor gathered from his experience that the unit method engendered a more intimate spirit of fellowship into the teacher-pupil relationship and a greater degree of self-initiated and purposeful industry into the work than was characteristic of his former experience. Observation also showed a growing capacity to pursue independent study and to organize and integrate experiences on the part of pupils. These, along with other subjective observations, offered sufficient stimulus and reward to the instructor for the work entailed in the initiation of the technique and the pursuit of the experimental stages.

Project Work in Undergraduate Physics*

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In the early days of science teaching in America very few students took laboratory work in general physics. The demonstration lecture system prevailed and only the genuinely interested students performed experiments along the lines indicated in the lectures. These experiments were usually voluntarily performed by students who wished to obtain answers to problems that their thought and study suggested.

With the growth of interest in physics which was spurred on by the practical engineering accomplishments of the past twenty-five or thirty years the physics laboratory became a place to which teachers and students turned their attention, confidently hoping that it would furnish even greater contributions to life in general. Because of this growing interest, courses in laboratory work grew in importance and students were offered the complete course in general physics as we know it today, consisting of lecture, recitation, and enforced, routine laboratory work.

The equipment of a physics laboratory is costly and the overhead expense of operating one is so high that, although a number of our wealthy institutions are adequately equipped, a great many colleges and universities have found it hard to meet the various needs of this work. The crowded condition of our schools since the World War has not made the problem easier.

Insufficient equipment, lack of help, and cramped quarters have been potent factors in developing a routine spirit and system that in many cases has prevented the better student (who never likes too much routine) from obtaining the thoughtful guidance and inspiration which would be of great profit to him. The necessity of serving overwhelmingly large groups has given the conscientious instructor little chance for leadership in planning and suggesting work of a nature to challenge the students of real ability and talent. The net result has been, in many instances, a general lack of interest and a sigh of relief when the year of general physics was completed.

A number of years ago the writer was informed that one of his students in the physics laboratory had built a crude arc furnace of fire brick and was carrying on experiments of his own in his boarding house. Upon investigation it was found that the youth had fused everything that he

* A paper read before the New Orleans meeting of the American Association of Physics Teachers.

could lay his hands on and had burned a hole in his landlord's dining-room table. His interest and zeal had risen to a high pitch and he was toiling several hours each night on a project that might well have been substituted for some of the less thrilling work in his laboratory manual. He is, today, a very successful engineer, having found the way himself with very little help from the laboratory.

Later, the continual disappearance of plates from a privately-owned stock of photographic material led to the discovery that two students in general physics were successfully photographing the alpha-ray tracks of Wilson with an unbelievably simple set-up that they had devised, somewhat secretly, from whatever happened to be lying around. A little encouragement set these young men to work several hours a day and they are both at the present time following physics professionally, as work of their own choice.

Still later, a young man constructed a camera out of a peanut can, attached it to a small telescope, and contracted "flu" while photographing the moon. He is now a very happy professional astronomer, having changed from the field of economics because of the boost that he gave himself by working on his own project in his own way.

These cases and others led the writer to believe that in every large class taking general physics and doing the routine laboratory work there are a few students who ought to be given the chance to work for the love of the work and who ought not to be held to the completion of a certain number of prescribed experiments that are often, through necessity, chosen to fit the equipment on hand, rather than for their educational value.

Several years of planning and observation have resulted in a scheme which seems to work well; it does not change things materially in the undergraduate physics laboratory for the majority of the students who take the work with no special desire for accomplishment beyond a reasonable gain in general culture, but it does give the promising student a chance to work along the line that suits him and in which he can best express his individuality.

All the students in the class start laboratory work together. For a time they all perform the routine experiments as given in the manual. Meanwhile the instructors carefully watch them and note the few who seem particularly apt. They seldom number more than ten per cent of the whole, and their superior "knack" is generally observable from the start. At the end of perhaps five months a list of these students, with pertinent notes concerning them, is handed to the head of the department, who, with the director of the laboratory, has an interview with each one.

This interview is quite serious. The student is told that he appears to

have mastered the routine and acquired the laboratory habit. He is told that perhaps he has gained all that he would get from the perfunctory performance of further prescribed experiments, and he is offered, as a rare privilege, the chance of working for the rest of the year (about four months) on a problem along any line of his choice. Usually he states his choice instantly and says that he has been thinking about it for some time and wishing for just such an opportunity. He is told to think it over carefully and report his choice in writing within a few days.

His statement is filed for future reference and he starts to work for himself. He is assisted in every way; encouraged to read about his subject; talked to freely and aided in his plan of action and choice of apparatus; but he is never formally instructed in connection with the project. He uses whatever is at hand and builds much of his simpler equipment. He keeps a notebook of his own which is checked up at intervals, and when his project is completed he writes it up in detail and presents the written report to the teacher in charge of the laboratory.

As in other project work the student frequently opens up a valuable and fruitful side line, and several times in the writer's experience a project started in the sophomore year has led to a master's thesis later.

The student's reaction is very satisfactory. He gains confidence in himself and interest in his work. He comes to feel that physics is a great field for him and he usually puts in twice as many hours as the course demands. He seldom wants to let go when he has finished and he nearly always feels that another month would have worked wonders. He usually follows it all up with several courses in advanced physics which he is free to choose.

The other students react favorably in a most interesting manner. They pick up interest in what is going on and they feel more at home with a subject in which their friends and colleagues are so deeply interested.

The projects chosen cover a wide range. Heat conductivity, resistance bolometry, elastic properties of metals, indices of refraction of liquids, e/m, and thermopile work have been studied. Improvements in apparatus to get around difficulties found by the student himself and designs of new pieces of apparatus, such as power units and amplifiers, have been very popular. Whatever the choice, the student is encouraged to go on with it, because the branch of physics in which it lies does not seem to matter. A student working on a self-chosen problem in heat learns more electricity or optics than if he were doing the routine laboratory work on these subjects.

The results of this project scheme seem to justify its continuance. It has served to stimulate the whole group. It has given the instructor a chance for leadership and it has given the apt students a chance to do things for themselves. It has turned young men toward careers in physics and has, in the writer's experience, served to humanize the subject.

Science Objectives at the Junior- and Senior-High-School Level

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During the past few years there has been a growing conviction among educators that one of the best ways to arrive at the causes of the weaknesses and shortcomings of our teaching in the secondary school, is to analyze the ideals, goals, aims, or objectives which our teachers are striving to attain. In that splendid report, "Teaching Science as a Way of Life," Tildsley[1] says: "Teachers in the long run move toward their real objectives. They never go beyond them."

It was to gather data which would help to throw light on the "real objectives" of the teachers of science in the secondary school that the senior writer[2] included in his 1930 questionnaire a section which asked that the major aims in science teaching be listed for each of the two secondary school levels. Replies were received from 393 schools, representing every state in the union with the exception of West Virginia. The section of the questionnaire regarding aims was filled in for the junior-high-school level by 114 schools, for the senior-high-school level by 115 schools, and for both levels by 117 additional schools. Forty-seven schools failed to utilize this part of the questionnaire. This same questionnaire was also sent to each member of the National Association for Research in Science Teaching, which will be referred to as the N.A.R.S.T. group in this paper. A large percentage of these members replied, with aims listed for both the junior- and senior-high-school levels. The replies from this group may be considered as representing what the experts in the field of science teaching think should be the real objectives in teaching science, while the replies from the teachers themselves should be representative of what objectives are actually functioning in the secondary school.

In the following paper the work of the senior writer has been largely directive while the actual work in classification of objectives has been done by the junior writer.

It is the purpose of this paper to point out the following significant results:

(a) To present the list of aims of science teaching which resulted from the entire study, and to show how wide-spread is the belief that each one listed is a "real objective."

(b) To show what difference of emphasis is placed on each of the objectives by the teachers of junior-high-school science compared to teachers of senior-high-school science.

(c) To show what difference of emphasis is placed on each of the objectives at each of the levels by the teachers compared to the answering members of the N.A.R.S.T.

Individuals filling in the questionnaire listed various numbers of objectives at the different levels. A few mentioned only one objective or aim while several expressed as many as ten aims. The majority specified a number of aims somewhere between these two extremes. However, no evidence was given to show that a person considered any one of the aims listed as bearing more weight than another. Due to this circumstance, no attempt was made to weight the objectives in dealing with them. In other words, any one aim was given the same weight as another, regardless of its position in the list.

The various aims were classified into four groups: first, all those aims from the teachers at the senior-high-school level; second, all those aims from the teachers at the junior-high-school level; third, all those aims for the senior-high-school level from members of the N.A.R.S.T.; and fourth, all those aims for the junior-high-school level from the N.A.R.S.T. group.

Each of the above groups was dealt with separately and independently, but in each case the same technique was used. Each aim was listed separately on a card. If two distinct aims were expressed in a compound sentence, they were separated, one being copied on one card and the other on another card. No attempt was made to classify the cards until all the aims of each of the four groups had been copied on their particular cards, and filed in their respective groups. In each case the wording of the aim was copied on the card exactly as found on the questionnaire, with the exception of where compound ideas were necessarily split. As an added precaution, cards of a different color were used for each of the four groups.

The next step was the classification of the aims in a given group. This classification was begun with an open mind, or in other words, without any preconceived idea of the final result. This attitude was taken to prevent as far as possible any forcing of the listed aims into previously prepared pigeon holes. Naturally there was bound to be some subjectivity in the grouping of certain cards where the aim was expressed in very general terms. However, the prime consideration throughout the whole analysis was

to gather into one group all those aims which were alike, although they might be expressed in different ways.

At the end of the above classification procedure, the answer to the first question was sought, namely, "What is the list of aims of science teaching

TABLE I

OBJECTIVES OF SCIENCE TEACHING SHOWING FREQUENCY OF MENTION

Science Objectives	*Number of responses*	*Per cent of total*
1. To help pupil understand his environment	123	11.6
2. To serve propaedeutic functions	113	9.8
3. To give information	97	8.4
4. To master scientific method of problem solving	96	8.3
5. To arouse interest in science	92	7.9
6. To explore the field of science	70	6.0
7. To impart knowledge about one's environment	67	5.8
8. To develop skills in doing such tasks as are likely to be needed in life. (utility)	66	5.7
9. To establish scientific thinking habits	61	5.3
10. To explore pupil's interests	60	5.2
11. To develop attitudes of appreciation of one's environment	56	4.8
12. To develop an appreciation of the value of health	47	4.1
13. To develop a scientific attitude toward all problems	46	4.0
14. To develop powers of observation, reasoning, etc.	30	2.5
15. To arouse interest in one's environment	29	2.5
16. Worthy use of leisure	28	2.4
17. To develop an appreciation of the work of scientists	20	1.7
18. Citizenship	17	1.5
19. To develop desirable study habits	10	0.9
20. Ethical character	6	0.5
21. Cultural	6	0.5
22. To keep alive childhood curiosity	5	0.4
23. Worthy home membership	4	0.3
24. To give basic experience	3	0.26
25. To develop a fact finding technique	2	0.18
26. To develop habits, skills, and abilities	2	0.18
27. Sex education	2	0.18
TOTAL	1158	100.00

which we get as a result of the entire study; and how widespread is the belief that each one listed is a 'real objective'?" The results of all four groups were pooled and arranged in Table I to show the various aims and the frequency with which each aim was mentioned.

The name of each objective as listed in Table I is an arbitrary statement which seemed best to express the idea involved in all the cards of a

certain classification. For example, under the heading "To help the pupil understand his environment" would be such expressions as, "To help pupils understand, adjust themselves to the world in which they live"; "To get pupils to understand themselves and what is best for them in relation to nature about them; and teach scientific interpretation of natural phenomena of every day life" and "Acquisition of knowledge leading to understanding of elementary forces of environment." Under the heading "To serve propaedeutic functions," would be listed, "To prepare for college" and "To develop skills needed for advanced study." Under the heading "To explore the field of science," would appear "Exploration as a basis for electives in senior high school"; "To orientate the pupils in the field of science"; and "To acquaint the student with the sciences taught in high school and college." Under the heading "To explore the pupil's interests," would be found "To give an attractive view of the content of all sciences, so that pupils may find out where their particular capabilities lie, and thus more wisely choose what they wish to study later"; "To explore the pupil himself"; "To provide experiences which will enable the pupil to discover the field of his dominating interests"; and "Discovery of interests, aptitudes, and abilities of students."

An examination of Table I shows that, with relatively few exceptions, all aims are expressed in terms of immediate objectives rather than in terms of ultimate goals. This seems to the writers to be significant because it has long been recognized that the general ultimate aims, as the "Seven Cardinal Principles," were not effective in the classroom. The immediate objectives, which in turn accomplish the ultimate goals, are the real factors which motivate teachers to better classroom work. As has been pointed out in the recent report of the Committee on the Teaching of Science of the National Society for the Study of Education,[3] "Objectives may be formulated (1) as statements that function directly in thinking, (2) as statements that describe methods of thinking, and (3) as statements that describe attitudes toward products of thought and toward methods of thinking." In other words objectives should be functional in the lives of the individual using them. It is interesting to compare this statement with the general list of objectives listed on page 409, and then to compare this list with the graphs in which the objectives named by the members of the N.A.R.S.T. have been compared with the teachers answering the questionnaire.

The second part of this study attempted to show the difference of emphasis placed on each of the objectives by teachers of junior-high-school science compared to the teachers of senior-high-school science. For this part of the study there were 538 separate responses at the junior-

high-school level and 505 at the senior-high-school level. Each of these groups was classified separately, as explained earlier in this paper and the percentage which any one objective was of the total number was computed separately for each group. These percentages were reduced to a graphic basis for ease of comparison. The results are shown in Figure 1.

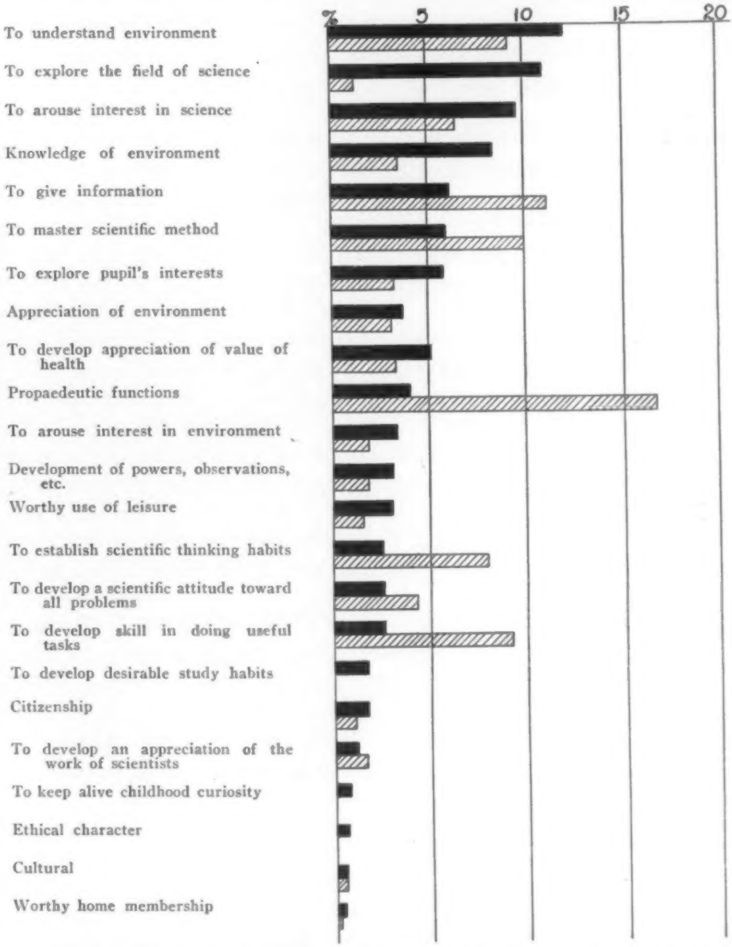

FIGURE 1. The Relative Emphases on Science Objectives for Junior-High-School (solid bars) and for Senior-High-School (single-hatched bars).

In this chart the most noticeable difference is found to exist in the propaedeutic and information objectives. Apparently the teachers in the junior high school have more fully conceived the rightful place of factual information. Morrison[4] says "The secondary school does not teach science and history and literature and language; it utilizes these elements of culture and others in educating the pupil." It is true that senior-high-school teachers have college entrance requirements with which to contend, but it is by no means impossible to meet these requirements while using subject-matter as a means to other worth-while ends. The real values which should come from the study of science can never be properly attained while the teacher is thinking foremost of preparing his students for college, or merely of giving factual information as an end to itself.

It is much to the credit of the senior-high-school teachers that so many place emphasis upon mastery of the scientific method, development of a scientific attitude, and the establishment of scientific thinking habits. Teachers of junior-high-school science should realize that if science ever expects to attain these worthy ideals, they also must shoulder their share of the responsibility. On the questionnaire which he returned, M. J. W. Phillips of West Allis High School, West Allis, Wisconsin, wrote, "The term *scientific method* is something which, when the average teacher attempts it, becomes a college method diluted, thus it fails and the pupil does not know what it is all about." Mastery of the scientific method, and the development of scientific thinking habits and a scientific attitude is vital for every potential citizen. Teachers of both levels of the secondary school should place more emphasis upon these objectives, while considering Mr. Phillips' suggestion as to why they have failed to accomplish more in the past.

In exploring the field of science the junior-high school leads by a large margin. The question naturally arises whether senior-high-school teachers consider this objective often enough. The junior-high-school student can never get his bearings completely in the differentiated fields of science. Junior-high-school science classes may give a fine start in this orientation work, but it can only approximate completion if carried out throughout the higher science courses.

Likewise, in exploring the pupil's interests, one finds the most support from junior-high-school teachers. This exploratory function is one of the most fundamental objectives in teaching any subject. When the gradual decrease in enrollment in physics is compared with the growing enrollment in general science, it is not difficult to conclude that the physics teacher, as well as the teachers of other senior-high-school sciences,

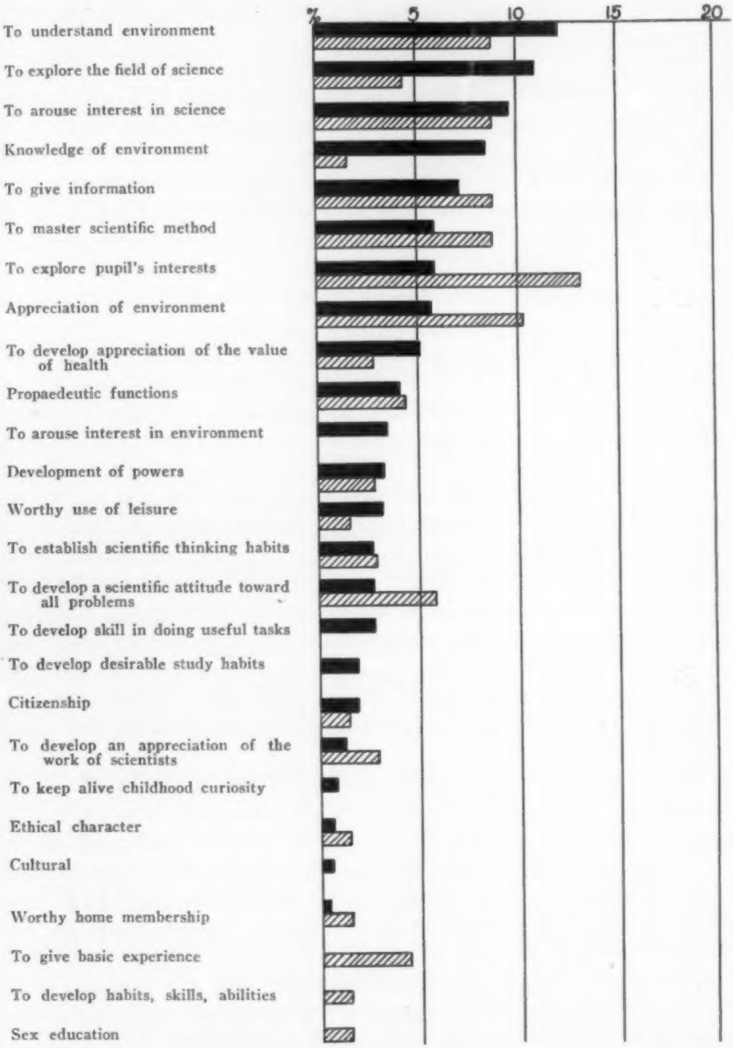

FIGURE 2. The Relative Emphases on Science Objectives for the Junior-High School as Judged by Junior-High-School Teachers (solid bars) and by members of the N.A.R.S.T. (single-hatched bars).

would do well to pay more attention to the exploration of the student's interests, aptitudes, and abilities.

The third part of this study was to show what difference of emphasis is placed on each of the objectives at junior- and senior-high-school levels by the teachers as compared with the members of the N.A.R.S.T. In this part of the study all four groups of classifications were brought into use. The objectives listed by teachers at the junior-high-school level were paired off with the objectives for the same level as expressed by members of the N.A.R.S.T. Likewise, the aims at the senior-high-school level given by the teachers were paired with those listed by the N.A.R.S.T. group. Figures 2 and 3, each reduced to a percentage basis, show the comparisons at the different levels.

One of the most interesting things noticed in Figure 2 is the difference of opinion in the use of the exploratory objective. The teachers put relatively high importance on the exploration of the field of science and relatively little emphasis upon the exploration of the pupil's interests at the junior-high-school level. On the other hand, members of the N.A.R.S.T. just reverse the case. In fact, members of the N.A.R.S.T. place more emphasis at this level upon exploration of the child's interests than upon any other objective. Apparently there are two distinct views of the explorative function. One is an orientation in the field and subject matter of science, while the other emphasizes the child himself, his interests, aptitudes, and tendencies. The writers do not wish to suggest that one point of view is right and the other wrong, but they do feel that exploration, thought of in terms of the fields and subject matter of science, should not hold a higher place in the minds of teachers than the exploration of the child himself.

The teachers place relatively great emphasis upon *knowledge* of environment, while members of the N.A.R.S.T. hardly mention it. On the other hand, the latter group place great emphasis upon *appreciation* of environment. It is difficult to know just what this means, but it might be interpreted to indicate a tendency for teachers to feel that if they impart plenty of knowledge about environment, then appreciation will result. Whether or not this is true, it will serve to call attention to a possible danger, because mere knowledge alone does not necessarily lead to appreciation. It is to the credit of the teachers that they place understanding of environment very high, which would indicate that many go beyond the imparting of knowledge, and use that knowledge to accomplish the broader aim of understanding.

Members of the N.A.R.S.T. place more emphasis upon scientific method, scientific thinking habits, and scientific attitudes at the junior-high-

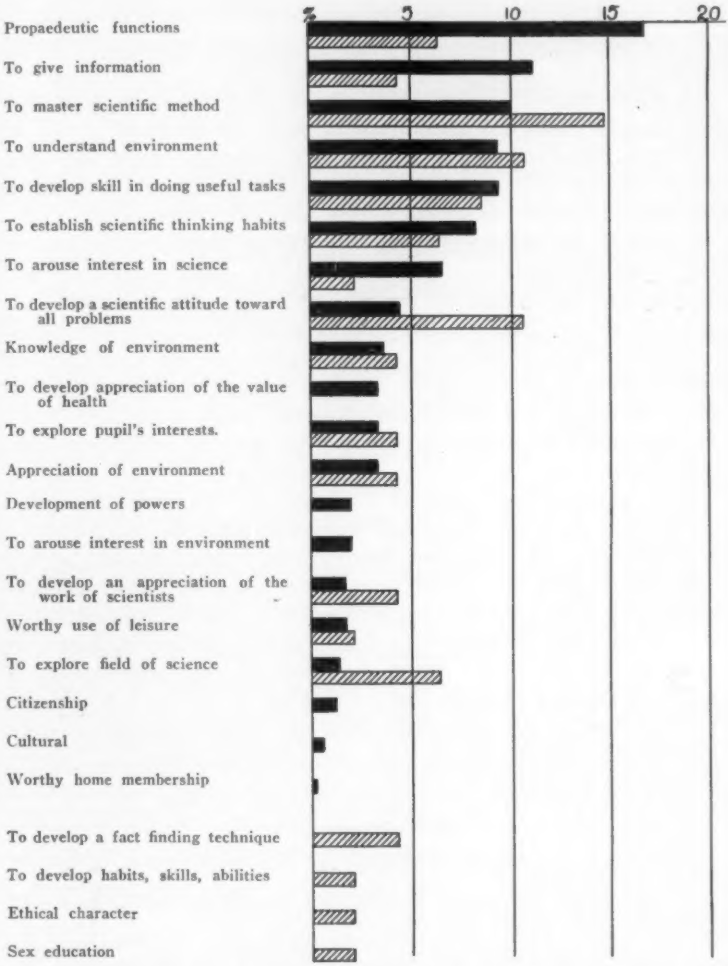

FIGURE 3. The Relative Emphases on Science Objectives for the Senior-High School as Judged by Senior-High-School Teachers (solid bars) and by members of the N.A.R.S.T. (single-hatched bars).

school level than do the teachers at that level. Methods of presentation can be adapted to pupils of junior-high-school age for training in the steps of scientific thinking. Problems worked out by the experimental

method should be the approach by junior-high-school science classes so that children may become habituated to this method of the thought process.

In figure 3 the outstanding classroom emphasis is placed on the propaedeutic and informational objectives. Doubtless the decreased enrollment in the specialized high-school sciences is a reflection of the disproportionate emphasis placed upon these two aims by the teachers of senior-high-school science.

Members of the N.A.R.S.T. place their greatest emphasis upon mastery of the scientific method and the development of a scientific attitude toward all problems. One cannot say that the senior-high-school teachers have ignored these aims. It is very encouraging to see how widespread is their recognition of these objectives. These aims would rise much higher in the teacher's list if it were not for the excessive weight given factual information as an end in itself, whereas such information should be used for the development of attitudes and techniques of study which would always open doors to knowledge, whenever and wherever needed.

In so far as aims are a criteria of actual work being done, the writers come to the general conclusion that teachers of junior-high-school science are doing their work better and with more understanding than teachers of the senior-high school. Teachers of neither level show much evidence of humanizing science through the development of an appreciation of the work of scientists. Teachers of the upper level seem to be held more closely by convention and college requirements, there appearing to be but little relationship between the major aims of the two levels. A less static condition at the senior-high-school level, and a closer coöperation between the two levels are suggestions which should result in an improvement in science teaching.

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A Plan for Developing a Better Technique in Giving Science Demonstrations

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Teaching by the demonstration method is an important aspect of science instruction. Consequently, there must be a plan or a method for making the demonstration as effective as possible. Repeated observations of classroom demonstrations have shown the writer that science teachers fail to comprehend its function. Very little, other than facts, is taught in the demonstration. In the majority of cases the important objectives of science are entirely forgotten or overlooked.

One of the major objectives of science teaching is to aid pupils in developing a method of solving problems. The teacher demonstrations in science classes can aid toward the attainment of this most important goal if they are organized around the elements of problem solving. This psychological arrangement will give pupils practice in the scientific method.

With the foregoing ideas in mind the writer has attempted to formulate a technique for giving class demonstrations. A preliminary study was made of the typical errors in demonstrations by beginning science teachers because provision should be made in the plan for the elimination of these common mistakes. During a period of three years the writer has observed thirty-six student-teachers in general science. The mistakes were recorded during the actual time of teaching as accurately as possible. It is needless to burden the reader with the details of such a tabulation and these are, therefore, omitted. The most frequent errors which were observed are as follows:

1. The apparatus was not ready for use.
2. The teacher failed to show how the demonstration fitted into the problem or the unit.
3. The teacher failed to direct the students' attention to the important facts of the experiment.
4. The teacher failed to allow the pupils time to record data.
5. The teacher failed to use the blackboard to aid the pupils in visualizing or comprehending a process, a plan, or the set-up of the experiment whenever the demonstration demanded it.
6. The teacher failed to make clear to the student the reason for employing a certain technique and a control for the experiment.
7. The teacher used more of the simple recall type of question than the reflective type of question.

8. The teacher used a vocabulary unknown to the majority of the students.
9. The persistent and continuous talking by the teacher did not challenge or stimulate pupils to talk or to ask questions.
10. The minor facts were given as much consideration as the major ones.
11. The teacher formulated the results and the generalizations rather than requiring the pupils to do so.
12. The teacher failed to emphasize the generalization.
13. The students' interest for further study was overlooked or not stimulated.
14. The teacher failed to aid pupils in applying a generalization when the pupils themselves were incapable of completing this final step in learning.
15. The teacher failed to encourage the pupil to suspend his judgment until adequate data upon the problem were obtained.
16. Insufficient drill was given in the formation of the generalization or its application.

A careful study of these difficulties shows that the greater number of errors are those pertaining to problem solving. In another investigation the writer found that the common errors made by pupils in general science are also those of problem solving.

An article by Downing[1] and the writer's classroom study of teachers' and pupils' errors in general science served as bases for determining the steps which should be included in a class demonstration.

The plan was repeatedly tried in the classroom before a satisfactory technique was obtained. As a result the following procedure is suggested:

1. Preview.
   Give a short presentation before the actual demonstration is performed. This presentation should cover these points:
   a. Set up a clear definition of the purpose of the demonstration.
   b. Indicate how the demonstration fits into the larger problem or unit of study.
   c. Aid the pupils to recall past experiences which will later be needed by them in interpreting the results of the demonstration.
   d. Raise questions upon the technic and the control of the experiment.
   e. Raise questions as to the manner of collecting and recording data.
   f. Develop a feeling for the need or the worth-whileness of the data.
   g. Ask pupils to set up a tentative hypothesis whenever possible, namely, suggestions as to what the possible results might be or should be.
   h. Teach the needed vocabulary.
2. Performance of the demonstration.
   a. Direct, through questioning or suggestion, the pupils' attention to important facts or observations.
   b. Present the material so that pupils will have a questioning attitude and wonder why this or that is true. This will later develop interest in further study.
   c. Recall the purpose of the experiment if necessary and through questioning aid pupils in properly stating the purpose.
   d. Use the blackboard whenever possible to illustrate an idea or to make the demonstration more meaningful to the student.
   e. Allow the pupils time to record the data. Supervise this activity because the accuracy of the students' interpretation partly depends upon his exactness.
3. Aiding pupils in the process of generalizing.
   a. Aid the pupils in selecting the major ideas. This may be done by asking

them to state the important ideas presented in the demonstration. The teacher must provide the proper conditions to enable the pupil in this process of abstraction. Proper guidance involves the following factors:

(1) Present many situations containing the element to be selected so that pupils can generalize for themselves.
(2) Avoid irrelevant ideas while demonstrating.
(3) Emphasize the major idea by contrasting it with an opposite or different idea.

b. Ask the pupils to state how each idea contributes to the understanding or the interpretation of the results.

c. Aid the pupils in synthesizing the smaller ideas into larger ones and finally into the important generalization.

d. Do not allow pupils to jump to a conclusion before the experiment is complete or until it has been tried under various conditions. Stimulate the student to suspend his judgment until he has reasoned with sufficient data at hand.

e. The pupil's understanding of the principle should be tested. A written response is desirable. The traditional method of writing experiments is not alluded to here; but rather the student may take an objective test, such as filling in the missing words in a series of paragraphs, answering questions, or illustrating the conclusions by means of diagrams.

4. Application of the generalization.

Aid the students in formulating the results and applying the information learned. The writer is aware that this step is a very difficult one, as well as that of generalizing; and all students are not able to reach this goal independently. It is a higher type of learning and therefore inherently difficult. In achieving this aim it is necessary for the teacher to set up various types of exercises and activities which will give the pupil practice in applying the principles learned. This may be done in several ways:

a. Present several mechanical devices which use the generalization taught in their operation. First present those in which the generalization is obvious and then others in which the generalization or the principle of operation is not quite as obvious. An example is given to illustrate the writer's idea. The generalization taught is that *Air Has Pressure.* The students may be asked to answer the following questions concerning the objects which are before him:

(1) Why is the football hard?
(2) How does the auto pump operate?
(3) Explain the principle of the barometer.
(4) How does the hand vacuum sweeper operate?
(5) Explain the principle of the siphon which you see working before you. The simpler situations are used first, then they become more complex. A series of such situations will enable the teacher to determine the level of the pupil's ability in transferring identical meanings.

b. A paper test may be given when the foregoing procedure is impossible. The following are examples of such exercises:

(1) The teacher can make diagrams of simple mechanical devices. Ask the student to indicate the scientific principle used and how it functions in the operation of the device. If the class is studying the principle that *Air Exerts Pressure,* simple diagrammatic drawings may be made of an atomizer, straw in a glass of lemonade, a lift pump, etc. Include other drawings which may use other principles to test the pupil's discriminative ability.
(2) Present certain problematic situations, the explanation of which requires an understanding of the generalization taught, such as, (a) Why do cold

water pipes "sweat" in the summer? (b) Why do persons' glasses get misty when going into a warm room from a colder one?

c. The student may be asked actually to make the application in setting up another demonstration. To illustrate: after the student has studied the way in which dry cells are connected and the advantages of parallel and series arrangement, he can then be given a bell and two dry cells and told to connect the bell in such a way as to make it ring as loudly as possible.

The complete plan has been tried by a number of beginning teachers in science. They state that the psychological processes of learning were clarified for them so that these elements were recognized in another teaching situation.

The available data procured up to the present by the writer tend to show that pupils get more from the demonstration and understand the generalizations better when such a plan is used. The data are highly indicative, though not conclusive, that pupils profit much from a systematic and carefully organized procedure in class demonstrations. These results will appear in a later article.

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Abstracts

General Education

Editorial 1. "Grades and Sex." *Educational Research Bulletin* (Ohio State University) 11:240-241; April 27, 1932.

The editorial offers comments upon the study of Registrar Gillis of the University of Kentucky of the marks made in English by 3,500 freshmen in 24 colleges in Kentucky. Gillis found that women teachers on the average gave boys and girls the same mark, but an examination of the records show that the girls are being penalized when taught English composition by women. On the other hand men teachers tend to mark the girls 50 per cent higher than they mark the boys. The same sex factor persisted in the marks in mathematics. This tendency is probably national in the opinion of many observers, according to the writer. If students wish their worth to be recognized by marks, boys should enroll in classes taught by women and girls should enroll in classes taught by men!

—C. M. P.

Brink, Laurence B. "The Fallacy of Ability Grouping." *School and Society* 35:427-429; March 26, 1932.

In the opinion of the author the weight of evidence is against homogeneous grouping. Ability grouping breaks down on the following points: (1) statistical invalidity; (2) administrative difficulties; (3) unsatisfactory criteria; (4) inadequate curriculum adjustments; (5) positive disadvantages of homogeneous grouping. The strongest reasons for rejecting ability grouping are social and ethical. —C.M.P.

Report of Committee M. "Requirements for the Master's Degree." *Bulletin of the American Association of University Professors* 18:169-184; March, 1932.

This committee report expresses opinions upon nine questions: (1) the significance of the degree as a step toward the Ph.D; (2) the proper length of the M.A. course; (3) the requirement of a minor in relation to the major; (4) the requirement of a thesis; (5) the desirability of a final comprehensive examination; (6) the essential requirements in a prerequisite bachelor's degree; (7) the acceptance of work done in other colleges or by extension; (8) the advisability of admitting M.A. candidates to undergraduate courses; and (9) the foreign language requirement. —C.M.P.

Maller, J. B. "Personality of the Candidates for the Edison Scholarship." *School and Society* 35:438-442; March 26, 1932.

In this study the author makes a comprehensive analysis of the results of the tests given to the 98 candidates for the Edison Scholarship during the years 1928-29 and 1929-30, and compares these results with those obtained from giving parts of these tests to other high-school students and high-school graduates. These groups are compared on the basis of: (1) background; (2) habits; (3) study and reading; (4) attitudes; (5) ideals. Real differences between the two groups are indicated by the differences in judgment, attitudes, and habits. —C.M.P.

Irvin, Forrest A. "The Work of the Teachers College in Preparation for Student Teaching." *Educational Administration and Supervision* 18:223-228; March, 1932.

With the saturation point approxi-

mately reached, and the teaching profession very much crowded, institutions in charge of the training of teachers are confronted with the task of selecting those persons as teachers who possess the requisite capacities and endowments. A solution to the problem involves: (1) as the supply of teachers outruns the demand, standards can and should be raised (the less promising candidates can be rejected); (2) as the task of the teacher enlarges and the demands are more exacting, the period of pre-service must be extended proportionately—probably a master of arts degree for elementary teachers; (3) the enriched and extended curriculum offered by progressive communities to its elementary school children argues convincingly for an adequate training superior in quality and quantity. A common weakness in teachers is the lack of mastery of subject matter. Along with this need of training in subject matter, attention must be paid to insight into child learning, mass management, extracurricular activities, and social education of the students.

—C.M.P.

Science Education in General

CALDWELL, OTIS W. "Science Essays by High School Pupils." *Science* 75:385-388; April 8, 1932.

The report of the A. A. A. S. Committee on "The Place of Science in Education" includes: an explanation of how an essay contest was financed; a description of the accurate and almost scientific plan by which each essay was judged; and a list of the winning pupils, their topics and the schools represented by them. —C.M.P.

DIAMOND, LEON N. "Testing the Test Makers." *School Science and Mathematics* 32:490-502; May, 1932.

The article is the result of an analysis of "all the available tests in general science and biology." Errors of validity on the part of the test-makers are discussed under the headings: (1) false generalization; (2) failure to keep up with scientific progress; (3) mistaking theory for proven fact; (4) lack of scientific classification; (5) lack of scientific definition; (6) errors of tradition. Errors of objectivity are discussed under (1) ambiguity; (2) spelling and typographical errors; and (3) lack of difficulty in test items. Eight biology tests and eight general science tests are listed with information concerning the number of questions, types of questions, and the number of errors in each.

The author assigns the errors to two basic causes: lack of information by the test-maker or his source of information and over-simplification due to the supposed needs of good pedagogy.

—A.W.H.

LANGVICK, MINA M. "The Summer School at Your Doorstep." *School Life* 17:197; June, 1932.

To those interested in natural science the author suggests a number of ways to spend a vacation that would be enjoyable and, at the same time, contribute to the improvement of teaching. In every community a wealth of plant and animal life and physical nature invites observation, study, and investigation. A kodak will help record beauty of structure and form and activities of living things that help illustrate concepts of science. Interesting walks may be marked ingeniously to form a progressive story of one's activities and to make the trails attractive to other ramblers. For those who wish to read extensively on science topics, two lists of books are suggested: "The Science Booklist" issued by the American Association for the Advancement of Science, Smithsonian Institution, Washington, D.C., and Circular No. 48, "United States Government Publications Useful to Teachers of Science," issued by the Office of Education, Department of Interior.

—F.G.B.

HOPKINS, B. S. and DAWSON, H. G. "An Experiment in Visual Education in Elementary College Chemistry." *School*

Science and Mathematics 32:353-363; April, 1932.

A discussion of the uses of slides and films in elementary-college chemistry, and a brief account of their experimental use with a selected class. Comparisons of school records with those of other comparable classes do not warrant any definite conclusions regarding the value of the visual materials used. The author thinks them valuable, however.

—A.W.H.

MULAIK, STANLEY. "Nature Counselor Preparation in Relation to the Status of Nature Study in Camps." *School Science and Mathematics* 32:391-400; April, 1932.

A summary of data from camp directors and nature-study counselors regarding training and experience of counselors, and other pertinent facts of camp oranization and procedure. Major points made are: (1) nature study counselors are inadequately prepared especially in methods of conducting camp activities involving children; (2) college subject-matter courses in science are not sufficient criteria for determining the fitness of camp counselors; (3) the task is a specialized one demanding particular personality traits and specific training; (4) "the nature study program should center in the camp environment and its unified series of nature phenomena. A carefully worked out course in nature study in the camp will keep in mind the child and his eternal curiosity, and will have in it opportunities for developing skills in handling various nature crafts." —A.W.H.

MARTIN, ROBERT E. "Mystery of America's Lost Empire Solved at Last." *Popular Science Monthly* 120:15-17; May, 1932.

Dr. C. W. Cooke of the U. S. Geological Survey believes that floods which carried soil from the hillsides into the valleys, filled up the lakes, and made stagnant water that permitted the breeding of mosquitoes—carriers of malaria and yellow fever—caused the decline of the great Mayan empire of Guatemala. This Mayan Empire, which probably flourished between 600 B.C. and 630 A.D., is thought to have had a population of more than 14,000,000 (practically the same as modern Mexico). The Mayans built magnificent cities amid intensively cultivated farms, acquired huge quarries, and constructed towering temples, massive public buildings, and great astronomical observatories. They were adept in painting, sculpturing, weaving and spinning, and were great scientists and mathematicians. They knew the uses of concrete and stucco, the medical properties of many plants, and the principle and application of perspective in architecture and painting. Their farmers domesticated corn, white and sweet potatoes, lima and kidney beans, cocoa, cotton, tobacco, and several cereals and vegetables. Unfortunately they had no beast of burden and never discovered the use of the wheel. They devised a calendar which stood without an error for nearly 5,000 years. According to Dr. Spinden, the Mayan calendar could have been used for 300,000 years before accumulating an error of a single day. Our present calendar will run only 3,300 years before it will develop one day's error. They conceived the idea of zero one thousand years before the Hindus, who, in turn, passed it on to the Arabs, and through them, to our European ancestors. —C.M.P.

KNOWLTON, A. A. "The Cultural Course in General Physics for Colleges." *School Science and Mathematics* 32:364-370; April, 1932.

The paper, read before the New Orleans meeting of the American Association of Physics Teachers, states the opinion of the author, formulated from his experience as a teacher of college physics. He minimizes the importance of attention to practical physics but stresses the understanding of basic laws and principles, particularly those of mechanics which are fundamental for all physics. New discoveries should be emphasized but the whole subject should be unified about a few large concepts. Mathematics is basic to quantitative physical concepts. The laboratory is a place for the "clarification of

ideas." Laboratory work should consist largely of unassigned tasks chosen by the student to answer questions in his mind. Coöperative-study classes and conferences, with the laboratory as an integral part of the constant quest for knowledge and understanding, are features stressed by the author. —A.W.H.

Science in Elementary Schools

PALMER, E. LAURENCE. "In the Woods in Winter." *Cornell Rural School Leaflet* 25:1-48; January, 1932.

Some of the animal and plant life that may be found in the woodland during the winter is outlined in this leaflet. The following are described: animals that make tracks in the snow; animals that live off the ground; birds; insects; and tree fruits and seeds. —C.M.P.

PALMER, E. LAURENCE. "Fall Insects." *Cornell Rural School Leaflet* 25:1-44; November, 1931.

The leaflet tells about insects that may be found in the fall: where to look for them; methods of locomotion; life history; how they protect themselves; food habits; sounds produced by fall insects. The folder contains illustrations. —C.M.P.

Science in Grades Seven, Eight, and Nine

MAYFIELD, JOHN C. "The Systematic Development of Learning Units in General Science." *School Science and Mathematics* 32:250-261; March, 1932.

An account of a teaching project now going on in the University of Chicago High School on the selection of teaching units, the determination of unit objectives, the organization of teaching materials, teaching procedures, and testing in general science. Selection is determined on the bases of comprehensiveness, significance to the pupil, and the presence of a unifying concept. Objectives are understanding of the large *unit concept* through the development of *secondary concepts* or *learning elements* and the wise selection of *contributing ideas*. Some illustrative material is given in the article. The features are re-interpretations of the "Morrison plan." —A.W.H.

BRIGGS, THOMAS H. "General Science in the Junior High School." *Teachers College Record* 33:599-609; April, 1932.

According to the United States Office of Education 16.93 per cent of the students in 1928 are enrolled in general science, a slight decrease since 1922. General science has failed to achieve as large a place in the curriculum as its advocates hoped it would. The reasons for this failure are probably many and complex. The author discusses each of the objectives toward which he believes a general science course should aim: (1) utility; (2) appreciation; (3) avocation; (4) social contacts; (5) scientific attitudes; (6) preparation. —C.M.P.

MCMURRAY, JAMES P. "Individualized Science Instruction in Junior-High School." *The High School Teacher* 8:97-98; March, 1932.

The article describes how individualized instruction in science may be done in a school where as little as two hours of the thirty per week are allotted to science. Administration, reference, and laboratory difficulties are not nearly as great as one might surmise. The results are worth while. Assignments in the East Orange (New Jersey) Junior-High school are made on a three-level basis. Discussion, laboratory work, reports, and so on, form an integral part of the work. The author believes that this method can be used in any school where science is taught. —C.M.P.

HOBART, ALICE TISDALE and NOURSE, MARY A. "How Half the World Works." *The National Geographic Magazine* 61:509-524; May, 1932.

The authors describe the primitive hand-made tools of toil in China. The depression in that country cannot be laid to unemployment caused by modern labor-saving machinery! The article is illustrated. —C.M.P.

CAMPBELL, SIR MALCOLM. "More Speed!" *Popular Mechanics Magazine* 57:705-709; May, 1932.

The author is holder of the world's land-speed record of 257.142 miles per hour made in the "Bluebird" at Daytona Beach, Florida. The author discusses his experiences in attempts to break land-speed records. He predicts a speed of 300 miles per hour within the next five years. The article is accompanied by illustrations. —C.M.P.

BAIRD, WILLIAM J. "Suggestions for Improving Instruction in General Science." *Educational Administration and Supervision* 18:104-114; February, 1932.

General science teachers may improve their teaching by: (1) being thoroughly familiar with the five steps in the technique of teaching; (2) having definite objectives in teaching general science based on activities, interests, and environment of the pupils; (3) knowledge of methods of teaching in general and more specifically in science; (4) adequate laboratory equipment; (5) adequate library references and supplementary texts; (6) making the laboratory room a real workshop; (7) use of pictures, slides, films, and other concrete material; (8) bulletin board; (9) collections and excursions; (10) school visitations. —C.M.P.

Science in Senior High School

HURD, A. W. "Report on the Experimental Use of Units in Physics. *North Central Association Quarterly* 6:408-412; March, 1932.

This report summarizes work done with experimental teaching units in physics under the sponsorship of the Committee on Standards for Use in the Reorganization of Secondary School Curricula of the North Central Association of Colleges and Secondary Schools. References are made to several published articles where more detailed information may be secured.

Apparent generalizations deducible from the experimentation so far carried on are: (1) careful selection of concepts to teach in science classes is an indicated necessity; (2) minimum essentials in class time, no assigned home work, and a project program for out-of-class time seem worthy of careful consideration; (3) unit experimentation is the process most likely to result in satisfactory reorganization; (4) poor achievement is due to poor planning; (5) a sequential curriculum in elementary and secondary school science would help solve some of our problems, especially that of time.

—A.W.H.

ENGELHART, MAX D. "Physical and Biological Sciences." *Review of Educational Research* 2:21-28; February, 1932.

More than 60 research studies are mentioned in this review. They are classified under the headings: (1) lecture demonstration versus laboratory work; (2) unit assignments; (3) visual aids; (4) drawing in connection with laboratory work; (5) reporting laboratory exercises; (6) general plan of instruction; (7) sequence of laboratory and classroom work and (8) miscellaneous.

The reviewer attempts to sum up the findings under most of the headings. Some of his statements or other comments follow in the order of the above list:

(1) Although most, if not all of these experiments are subject to certain limitations, the consistency of the findings probably justifies the conclusion that demonstration lectures by a skillful instructor are satisfactory substitutes for a considerable portion of the usual individual laboratory exercises; (2) the complexity of the experimental factors and the failure to secure adequate control of important non-experimental factors, particularly the zeal and efforts of the teachers, render the conclusions of the above experiments of doubtful dependability; (3) all of these experiments were subject to limitations and the results should be considered only as suggestive; (4) these experiments indicate value in locating structures equal to drawing diagrams, in labeling ready-made diagrams superior to drawing original

ones, in making diagrammatic drawings rather than picture-like ones, and in inking drawings after first making them in pencil; (5) . . . the instructions in regard to note books (in all experiments) which were compared seem to overlap to such an extent that it is difficult to interpret the findings. A possible interpretation seems to be that the notebook requirements should be flexible and should provide for resourcefulness and initiative on the part of the student; (6) these experiments . . . do not appear to justify any generalization in regard to the relative merits of the plans of instruction compared. The experimental factor is so general that the application of any of the indicated methods in a particular case is likely to be influenced to a significant extent by the resourcefulness, zeal, and skill of the teacher; (7) the facts and evidence from a number of other investigations suggest that for a particular teacher that method is best which he prefers; (8) twenty-one experiments are reviewed under this heading. In general the conclusions are undependable but some are interesting and suggestive. —A.W.H.

WEBB, HANOR A. "How the Last Two Elements Were Found." *School Science and Mathematics* 32:475-486; May, 1932.

This is a description of how Virginium (Number 87) and Alabamine (Number 85) were found, thus completing the list of 92 chemical elements, told in Webb's characteristic style. —A.W.H.

CALDWELL, OTIS W., and WELLER, FLORENCE. "High-School Biology as Judged by Thirty College Biologists." *School Science and Mathematics* 32:411-427; April, 1932.

A check list was prepared by analyzing eleven textbooks of biology. A condensed version was sent to 37 college teachers of biology. Thirty of the 37 gave their reactions with the following concensus: (1) increase the sub-divisions of biology and give brief definitions of each; (2) give less attention to classification of animals and plants but name the large divisions and give a description of one type form for each; (3) the course should emphasize the structures and functions of plants and animals including man. Further suggestions were to include a consideration of the following: (1) geographic distribution of plants and animals; (2) human behavior and mental hygiene (relatively small emphasis; (3) material on alcohol, tobacco, and drugs, not extensive treatment); (4) care of special human structures, public health, study of foods; (5) economic value of plants and animals, insect pest control. conservation of wild life; (6) processes of metabolism; (7) heredity and environment (restricted); (8) biographies of famous biologists. —A.W.H.

"Symposium: Chemical Education in America." *Journal of Chemical Education*. 9:667-750; April, 1932.

Several noted chemists contributed to this series of papers on the history of Chemical Education in America given at the Buffalo meeting in September, 1931. Among the contributors are: Lymon C. Newell, John N. Swan, C. A. Browne, Harrison Hale and F. B. Dains. —C.M.P.

NELSON, JEAN. "Organizing a Biology Field Trip." *University High School Journal* (University of California) 11: 253-293; March, 1932.

The author gives a detailed description of how biology field trips in the University High School are organized to obtain maximum results: (1) choosing the place; (2) fixing a date; (3) meeting school requirements; (4) preparing work sheets; (5) preparing the class; (6) discussing the trip itself; (7) preparing the student teacher; the work of the teacher on the trip; (8) the work of the students; (9) the work of the student teacher; (10) the follow-up work after the trip. The work sheet for the Muir Woods trip, an all-day trip, is given in full. —C.M.P.

LONG, HENRY J. "An Experiment in Laboratory Technic." *Journal of Chemical Education* 9:913-915; May, 1932.

The author describes a method of im-

proving the laboratory technic of high-school chemistry students. Each student is given a "laboratory technic" grade amounting to one-tenth of his final grade. The author believes that this device not only improves the appearance of the laboratory room but also considerably improves the laboratory technic of the students. —C.M.P.

"Symposium: Some of the Unfamiliar Elements." *The Chemistry Leaflet.* 5: 1-32; April 21, 1932.

A description of several of the more or less unfamiliar elements, including those recently discovered. A very interesting table showing the order of the discovery of the ninety-two elements, as well as the name of the discoverer and the date, is included. —C.M.P.

Pierce, Bruce M. "Is Raw Milk a 'Raw Deal'?" *Scientific American* 146:212-214; March, 1932.

The author offers conclusive evidence, backed by the leading medical journals of this country, that raw milk is no longer a safe food. Many recent epidemics of typhoid fever, diphtheria, and septic sore throat have been traced to contaminated milk. Pasteurized milk loses none of its nutritive value and very little of its vitamin content. The process of pasteurization is described. —C.M.P.

Cochran, Doris M. "Our Friend the Frog." *The National Geographic Magazine* 61:629-654; May, 1932.

The author, who is assistant curator in the United States National Museum writes very interestingly about the life of the frog. There are thirty illustrations, including sixteen paintings from life. Descriptions of twenty-six different kinds of frogs enhance the value of the article. —C.M.P.

Davis, Walter Burke. "Snakes of Summer Township." *The High School Journal* 15:119-123; March, 1932.

The article describes the experiences of a group of high-school boys in collecting and studying snakes in Guilford County, North Carolina. Not only did the boys have a delightful outing, but, at the same time, their experiences with snakes gave them an interest in science that will probably be permanent and lead to other worth-while explorations in biology and allied fields of science. —C.M.P.

Durflinger, G. W. "Shall Modern Physics Be Included in the High School Course?" *School Science and Mathematics* 32:328; March, 1932.

A summary of returns from 211 high school and 33 college and university teachers, selected at random in the United States, giving their opinions on 88 selected topics touching on modern concepts in physics, as to whether or not these topics should be included in the high school course. "The topics dealing with ionization, radioactivity, and the electromagnetic wave theory are the ones most desired and should be taught. The topics under the headings X-rays, photoelectric effect, quantum theory, and the theory of relativity are, in general, the ones the teachers think ought not to be taught.

"None of the 88 topics listed did the teachers want in the laboratory experiments.

"Over 91 per cent of the high-school teachers said they used supplementary physics material in addition to the textbook.

"Only 43.33 per cent of the teachers said they use all the material of the textbook.

"The three reasons ranking highest among those for not completing the textbook are: (1) lack of time, (2) material too difficult, and (3) not in state syllabus." —A.W.H.

Steel, Ernest W. "Does Your Water Garden Grow Mosquitoes?" *Hygeia* 10:719-721; August, 1932.

The author gives a brief discussion of the development of mosquitoes in ornamental garden pools. He suggests several methods of destroying these pests but recommends fish as the most satisfactory means. For pools south of a line through northern Virginia and Tennessee, topwater minnows give excellent results. For

pools north of this line, roach or golden shiner, mud minnows, and varieties of sunfish are suggested. Top-water minnows may be used in the northern states but will not winter in out-of-door pools.

—F.G.B.

LILLINGSTON, CLAUDE. "Pioneers of Medicine—William Konrad Roentgen." *Hygeia* 10:707-709; August, 1932.

This article gives valuable and interesting information concerning the life and work of Roentgen, the discoverer of the X-ray which has proved to be of inestimable value in medicine and surgery. Outstanding occurrences in his life are considered, such as those related to his childhood and early education, his close association with August Kundt, his university teaching, the discovery in 1895 and subsequent testing of X-rays, the formal presentation in 1896 of his famous discovery before the Physical-Medical Society of Wurzburg, demonstration of X-rays before the Emperor of Germany, appointment as director of the Institute of Physics in Munich, acceptance of the Nobel Prize in Physics, a brief discussion of the value of the great discovery to man, and his death in 1923 from cancer—a disease which has been successfully treated in many patients by Roentgen rays. —F.G.B.

HOLLIS, RALPH C. "Physics by an Individualized Method." *School Science and Mathematics* 32:324-327; March, 1932.

The article gives an account of an individualized method in senior high school physics which substitutes study and laboratory work for the usual class recitation. Introductory lecture demonstrations, assignment sheets, and flexibility in the choice of activities for pupils of different interests and vocational expectancies are notable features. —A.W.H.

STEVENS, CLARENCE P. "The New Courses in High School Chemistry." *School Science and Mathematics* 32:244-249; March, 1932.

Stevens gives an account of an investigation seeking to determine the extent of courses in "pandemic or laical" chemistry, i.e., chemistry for the layman as contrasted with that for the future chemist. Of 89 schools reporting, but a small number offered complete pandemic courses (4.5 per cent). The types about equally common were quasi-pandemic courses and college preparatory courses. Ten objectives for chemistry in rank order of teacher opinion are listed along with five guiding principles for pandemic chemistry. Some difficulties with pandemic courses are given. More time to chemistry in high school is recommended. —A.W.H.

McDOWELL, HAZEL A. "Methods of Teaching Biology." *School Science and Mathematics* 32:261-267; March, 1932.

There are given in the article some reactions on (1) how biology may contribute to the leisure time, health, and ethical objectives; (2) how to manage the problems of rooms and equipments; (3) how to initiate the course; (4) how to supplement the text; (5) how to manage the specimen problem; and (6) how to secure proper methods of biology study.

—A.W.H.

PERRY, WINIFRED. "Biology Teaching and Visual Aids." *School Science and Mathematics* 32:465-474; May, 1932.

Helpful suggestions on various kinds of visual aids are offered, with information showing where some materials may be obtained. —A.W.H.

POTTENGER, F. M. "Conquering Tuberculosis." *Hygeia* 10:305-308; April, 1932.

The author discusses the decline in death rate due to tuberculosis and the reduction in the number of cases of infection as a triumph in scientific medicine. The control of tuberculosis was brought about through an understanding of the important scientific, social, and economic aspects of the disease, such as proof of the transmissibility of the disease established by Klencke in 1843; the discovery of the tubercle bacillus announced by Koch in 1882; development of means of prevention based upon the theory of infection; and an understanding of the effects of nutrition, housing conditions, economic status, and occupations upon individuals.

—F.G.B.

New publications

Craig, Gerald S., Burke, Agnes, Baldwin, Sara E., Hurley, Beatrice D., Condry, Margaret G., and Johnson, Goldie. *Pathways in Science.* (6 vols.) New York: Ginn and Company, 1932. $0.76 each.

Book I. *We Look About Us.* 175 p.
Book II. *Out-of-Doors.* 269 p.
Book III. *Our Wide, Wide World.* 306 p.
Book IV. *The Earth and Living Things.* 308 p.
Book V. *Learning About Our World.* 384 p.
Book VI. *Our Earth and Its Story.* 425 p.

Science teaching in American public schools during the last two decades has witnessed at least two major curriculum trends or innovations. The first was the introduction of general science into the curriculum about 1910 with its rapid growth and the subsequent decline of some of the other sciences. The second major trend has been the movement to extend the science curriculum down into the elementary grades and thus make possible a continuous science program beginning at the elementary school level and extending on into the university. This last trend has especially characterized the last decade and has been emphasized in the *Thirty-first Yearbook* of the National Society for the Study of Education entitled "A Program for Teaching Science."

Many individuals have made essential contributions to the developments in elementary science, but probably no one has made a greater contribution than has Gerald S. Craig, one of the authors of the above-listed, supplementary readers in elementary science. The Pathways in Science series is based on research studies and classroom experiences. The research studies include analyses of children's questions in science, of educated laymen's needs in science, of courses of study, of worth-while scientific concepts, and of vocabulary studies. Each author is a classroom teacher of science and the practical knowledge gained of the laws of learning have been made evident in each book of the series.

The content and vocabulary of each text is within the experiences and understandings of the children of the grades for which they have been written. Each volume represents a year's work in a correlated six-year program in science. There is a teacher's manual to accompany each book.

The content of each text has been organized into large units, involving a series of problems, pertaining to both biological and physical science. Each unit contains a series of "things to do and to think about." Boys and girls will find the books delightful reading.—C.M.P.

Heiss, Elwood D. *An Investigation of Content and Mastery of High School General Science Courses.* East Stroudsburg, Penn.: Elwood D. Heiss, 1932. 118 p. $1.50.

This is a dissertation for the doctorate, the purposes of which is threefold: (1) to discover the basic instructional materials now used in general science courses; (2) to determine the extent of mastery of the basic instructional material of general science, and (3) to study the relation of

intelligence to achievement in general science.

The basic instructional materials which constitute the nucleus of the modern, general-science course were derived by analysis of seven recent general-science texts. The materials were organized in twelve units of study. The extent to which these basic instructional materials are mastered was determined by an extensive testing program. Results of the Terman Group Test of Mental Ability were used to determine the relation of intelligence to achievement.

From the extensive studies, the author has drawn the following conclusions:

(1) A common core of instructional materials has crystallized which forms the nucleus of the present-day ninth-grade general-science course;

(2) Most of the facts and principles of science developed in general-science courses are not being mastered by a large percentage of pupils exposed to them;

(3) There is considerable variation in the extent of mastery of the units of subject matter of general science and also great variation in extent of mastery of the various topics within the units themselves;

(4) Intelligence is a factor which conditions the achievement of pupils in general science. —F.G.B.

FRANK, GLENN. *Thunder and Dawn.* New York: The Macmillan Company, 1932. 404 p. $3.50.

In this book the President of the University of Wisconsin presents the outlook for western civilization with special reference to the United States. In the reviewer's opinion, the author makes an especially keen analysis of the contributing factors and causes of the present social order. Science, religion, education, economics, and politics are listed as contributory factors. Merited attention is paid to the prophets of doom and to those who decry science, and especially the science that relates to the machine and technology, as the most important factor in the social quagmire in which we find ourselves. The author presents sixteen indictments against the machine but comes to the conclusion that "technical progress is the ally rather than the antagonist of social progress. The machine order has not failed us. It is the economic order that has gone awry . . . the machine economy offers potential freedom from drudgery, poverty and insecurity. . . . The machine economy is a tool of emancipation that Western man has not yet mastered the wit to use wisely."

The reviewer recommends this book to every science teacher interested in the sociological implications of the subject he is teaching. It maintains a sane balance between the views of those on the one hand who pessimistically deride the contributions of science to modern civilization and those, on the other hand, who over-enthusiastically believe science to be the cure-all for society's aches and pains. —C.M.P.

HOLLEY, CLIFFORD, and LOHR, VIRGIL C. *Mastery Units in Physics.* Chicago: J. B. Lippincott Company, 1932. 700 p. $1.88.

This book aims to apply the tenets of the "Morrisonian mastery technique" in the field of secondary-school physics. It includes eleven teaching units, each of which aims to unify the content around some particular group of physical principles. Introductory to these units is a section on, "The Tools of the Physicist" which is not called a unit by the authors. Units I to IV include the portions of the subject matter usually included in mechanics of solids and liquids. These unit headings are: "The Molecular Nature of Matter," "The Effects of Gravitational Forces in Fluids," "The Effect of Force in Producing Motion" and "The Accomplishment of Work." The remaining units are very much like the conventional divisions of physics—heat, sound, light, magnetism, and electricity.

Each unit is prefaced by an overview which is a brief summary of the unit content to follow. The content is classified under assimilative material, which includes laboratory experiments usually found in laboratory manuals, explanations and descriptions, many illustrative photographs and diagrams, and questions and

problems; brief suggestions on the recitation with suggested topics for recitation; and some topics for further study and investigation evidently intended for the more capable pupils.

The style seems fairly simple and understandable and the authors have tried not to neglect the many applications of physics in everyday life, although they are always secondary in the discussion to the laws and principles of physics.

It is difficult to evaluate a course before it has been used by the reviewer. "The proof of the pudding is in the eating." Apparently it has worked out well with pupils in the University of Chicago High School. Whether it will be as well adapted to pupils in our public high schools, who are probably of a lower average degree of ability, remains to be tested by use in these schools. Peculiarly, to the reviewer, the book is valuable because of its comprehensiveness rather than for its arrangement. It is encyclopedic in character in that it touches upon most of the topics usually associated with high school physics. As with most textbooks in physics, it includes too much content for a one-year course, but this is not necessarily a drawback if the instructor exercises good judgment in selecting content to suit the needs of his particular group of pupils. It would help instructors if mastery tests were included in the text or procurable in separate form. A high degree of mastery of the content cannot be hoped for even from the better pupils in our public high schools. Hence one may wonder what the title "Mastery Units in Physics" implies. What points of information, what concepts, what principles or laws, what understandings, what appreciations, or what attitudes will these units give which make the book superior to other books? It would help to have them stated somewhere.

The book shows much careful work by the authors and will undoubtedly interest teachers who have heard so much about the "Morrisonian unit." Without question, it will be a splendid reference book for any school. It compares favorably with other textbooks on the market.
—A.W.H.

Thomson, Sir J. Arthur. *The Outline of Natural History*. New York: G. P. Putnam's Sons, 1931. 720 p. $5.00.

Students of natural science will be delighted with "The Outline of Natural History." In this book, Thomson accentuates his unusual abiliy to present materials of science in a clear, concise, and fascinating manner, making them interesting and useful to the general reader as well as valuable to the special student and professional scientist. The reader is brought into intimate association with many common American and British forms through inquiry "into the everyday life of animals and the diverse ways in which they have solved the perennial problems of hunger and love, foothold, and persistence." Sixteen chapters are given to a discussion of the lives and habits of mammals, their haunts, and the care which the parents give their young. Other chapters relate to birds and their ways, reptiles, amphibians, fishes, molluscs, spiders and their relatives, insects and their ways, crustaceans, worm-like animals, sponges, and amoeba as a representative of the simplest animals. A discussion of evolution is given in the last chapter. The illustrations used in the book are excellent nature photographs.

"The Outline of Natural History" is a condensation of the "New Natural History" written by Thomson and published in three volumes. Much new material has been added to the new volume.—F.G.B.

Hance, Robert T. *The Machines We Are*. New York: Thomas Y. Crowell Company, 1932. 382 p. $3.00.

This book consists of thirty chapters the majority of which were presented as lectures over the University of Pittsburgh Radio Studio of Station KDKA. The author, Professor of Zoölogy, University of Pittsburgh, states that the "chapters are neither intended to be a complete compendium of biological information nor are they presented as a guide to biological practice . . . but merely to indicate in the most general sort of way the lines along which we are trying to analyze our own make-up and to direct our destinies."

The chapter headings suggest topics that are of general interest and of value to the

lay reader as well as to the student of biology, such as: "We Chart our Lives"; "A Biologically-Minded Age"; "How Do We Inherit?"; "What Do We Inherit?"; "Can Heredity Be Changed?"; "What Can We Do about It?"; "Boy or Girl"; "Through a Microscope"; "Movement"; "Competing with Methuselah"; "Our Relations With Other Forms of Life"; "The Balance of Nature"; and "What Is It All About?"

Each essay, although an integral part of the whole, is written in such a way that it is relatively complete in itself. A few authoritative references are given at the close of the book.

The book is a clear, non-technical discussion of biology which should prove to be of interest and practical value to the general reader. —F.G.B.

Causey, David. *Uninvited Guests.* New York: Alfred A. Knopf, 1932, 120 p. $2.00.

The author describes, in a stimulating way, many of the common animal parasites that live in and on man. He emphasizes their life histories, how they gain entrance into the human body, how they get out of the body, and the diseases and discomforts which they cause man and other animals. In the last chapter various ways are suggested by means of which man can avoid parasites.

This book is written in an attractive style and, at times, in a light vein. The illustrations of the various forms indicate the outstanding characteristics but are often caricatures. The topic discussed by the author is of interest and extreme importance to everyone. The book should stimulate further reading about the important but "uninvited guests" that live in close relationship with man. —F.G.B.

Holy, T. C. and Sutton, D. H. *List of Essential Apparatus for Use in High School Sciences.* Bureau of Educational Research Monographs, No. 12. Columbus, Ohio: Ohio State University, 1931. 36 p. $0.75.

The present stage in the evolution of high-school science calls for four years of science: first year——general science; second year——biology; third and fourth years——chemistry and physics or physics and chemistry. "The trend in recent years has decidedly been from science instruction as a textbook course toward the experimental type." "The trend is toward laboratory teaching and the items of laboratory apparatus are receiving more attention." The bulletin gives lists of apparatus for the high-school science course and in a measure evaluates each piece of apparatus as checked on a questionnaire as necessary, desirable, or unnecessary. —W.G.W.

Black, N. Henry and Committee. *Equipment, Apparatus, and Materials for Teaching Science in the Secondary Schools of Massachusetts.* Department of Education Bulletin No. 8, 1930. Boston: Board of Education. 45 p.

This report is confined to the four almost universally taught sciences: general science (grades 7, 8, 9), biology (grade 10) and physics and chemistry in either order (grades 11 and 12). The committee planned for classes of twenty which they consider maximum for efficient work. The report discusses equipment for schools of different sizes, laboratory and lecture-room equipment and furniture, and the care and purchase of equipment. It gives lists of apparatus and material for the four science courses. There are excellent diagrams and photographs of laboratory and demonstration rooms. —W.G.W.

New York State Department of Education. *Elementary School Science—A Tentative Syllabus for Elementary Schools, Grades 1–6.* Albany, New York: State Department of Education, 1931. 109 p.

The syllabus was drafted by A. K. Getman of the State Department of Education, G. S. Craig of Columbia University, and E. L. Palmer of Cornell University. The materials of the syllabus were critically studied and evaluated by teachers in the State Teachers College, Buffalo, New York; by graduate students in Columbia and Cornell Universities who were interested in the teaching of science in elementary schools; and by teachers in

twenty different public schools in New York State. The manuscript was then revised for publication by Miss Jessie J. McNall of the Potsdam Normal School with the assistance of an advisory committee.

Seven major objectives guided the committee in selecting content of instruction and in suggesting appropriate methods of organization and teaching. The content objectives included in the syllabus are organized under seventeen headings. The subject-matter included under these headings in the different grades is indicated by topics that are within the experience and understanding of the pupils. At the beginning of each unit of instruction there is a statement indicating the phase of the content objective to be emphasized and the phase of the scientific principle involved. Following this statement, a number of elements are listed which in their development contribute to the attainment of the content objective. For each unit there is given a suggested procedure and a number of activities that include materials and methods of teaching. A carefully selected bibliography of references and materials for pupils and teachers is included.

This tentative syllabus is a constructive piece of work. It represents a distinct contribution in the field of science at the elementary-school level and will be of value not only to teachers in New York State, but to all who are interested in teaching elementary science. —F.G.B.

Cleanliness Institute. *School Service Publications*. New York (45 East 17th Street): The Institute.

In teaching cleanliness as an avenue leading to health and public welfare, teachers may receive valuable and reliable aid from School Service, Cleanliness Institute, which has prepared excellent supplementary materials that are available at cost. Review copies are sent to teachers and administrators on request. A few of its splendid publications are:

Broadhurst, Jean. *The Animal Way*. 1928. 54 p. $0.18.

This attractive primer, suitable for kindergarten, first, and second grades, tells through stories and pictures how different animals keep clean. A picture supplement from which colored pictures of animals may be cut and mounted in their proper places in the story and directions for using the book accompany the primer.

Hallock, Grace T. *After the Rain*. 1927. 112 p. $0.25.

This supplementary reader for grades 3, 4, and 5 gives a series of stories describing cleanliness habits of children in France, Japan, Italy, England, Poland, Finland, Africa, and Holland. A full-page illustration in color is given for each story. Suggestions for its use accompany the reader.

Hallock, Grace T. *A Tale of Soap and Water*. 1928. 96 p. $0.15.

This reader, suitable for grades 7, 8, and 9, describes the ways "in which people through many centuries have kept themselves, clothing, and surroundings clean." A bibliography relating to soap and water is included. The reader is accompanied by directions for its use.

Kimball, Alice Mary and Hopkins, Mary Alden. *The Judd Family*. 1931. 118 p. $0.15.

This is a supplementary reader for grades 6 and 7 telling the interesting story of changes in sanitation in home life in America from 1730 to 1930.

Peter, W. W. and Hallock, Grace T. *Hitch-Hikers*. 1930. 54 p. $0.15.

This booklet traces the avenues by which micro-organisms causing communicable diseases pass from the sick to the well. Definite suggestions are given for breaking these lines of passage. It is suitable for teachers and as reference material for the upper grades.

Munson, C. Margaret. *Outlines for Cleanliness Teaching*. (Section I for grades 1, 2, and 3; Section II for grades 4, 5, and 6; Section III for grades 7, 8, and 9), 1931. Free.

These outlines, suggestive for a cleanliness program, have been compiled after careful analysis of one hundred courses of study. —F.G.B.

Patch, Edith M. *Holiday Hill*. New York: The Macmillan Company, 1931. 135 p. $2.00.

On a visit to this interesting home of plants and animals, called "Holiday Hill," one observes great granite boulders brought here many years ago by a glacier; an arbor vitae thicket, the home of chickadee and his family; the evening primrose and its night visitor; Chlamys, the beetle; the garter snake; the elm tree, an old favorite with children and birds; blueberries; bayberries; bearberries; wintergreen; violet-tip, the butterfly; jun-

co; and little snow-shoe rabbit. The book is beautifully illustrated by photographs and drawings of the plants and animals that live on "Holiday Hill."

The story is written in a dignified, direct style, is accurate in content, and gives a clear and enticing picture of an attractive hill where boys and girls as well as adults would enjoy a pleasant holiday. The book is the third of a series of nature stories of which the others are *Holiday Meadow* and *Holiday Pond*. —F.G.B.

JAMISON, LOUISE. *Mother Nature's Little People*. Dansville, New York: F. A. Owen Publishing Co., 1930. 128 p. $0.72.

The author introduces boys and girls to common animals, such as moths, butterflies, wasps, grasshoppers, crickets, beetles, ants, spiders, and toads. These animals tell through conversation with each other, the stories of their life activities. In spring, the awakening time of the year, the animals emerge from winter conditions and begin the busy life of providing for succeeding generations. With the approach of fall and winter each animal, in his own way, prepares for the survival of his kind through the winter. The book is illustrated by eleven full-page and a number of small-line drawings by Kennard Harder. It is a nature reader appropriate for boys and girls of the third- and fourth-grade levels and is an interesting addition to the elementary-school library. —F.G.B.

HARNEY, LAURA B. *The Skycraft Book*. New York: D. C. Heath and Company, 1932. 338 p. $1.08.

This excellent little book is valuable as a reference for use in the upper elementary grades and in junior- and senior-high schools. It includes twenty-six chapters under seven larger divisions which have the following titles: "History and Romance"; "Aircraft Lighter Than Air"; "Aircraft Heavier Than Air"; "Motorless Craft"; "Rules and Regulations"; "Some Facts and Figures"; and "Making Model Planes." Explorations in the Arctic and Antarctic, some clear, simple, scientific explanations of airplanes and balloons, parachutes, and gliders, how to earn a pilot's license, and some interesting facts concerning air travel are among the topics treated. Written by a science teacher in a junior-high school, who is a licensed airplane pilot (an unusual combination), it is easy to see why it fits so well the needs of all those pupils who have naturally become interested in air transportation and the building of models.

—A.W.H.

HAWKS, ELLISON. *The Book of Electrical Wonders*. The Dial Press, 1931. 316 p. $3.00.

This is one of the interesting books that boys like. It is popular in style and packed with excellent classroom science. It is well illustrated and has 40 full-page half-tones. The subject matter considers: how electricity is produced; power stations; hydroelectric schemes; electric lighting; amazing temperatures obtained from electricity; invention of the telephone; telephone exchange; telegraphing without wires; wireless telephone; X-rays and their use in medicine and industry; electric transmission of pictures; television.

It is a reference book of value for supplementary work in general science.

—W.G.W.

WEAD, FRANK. *Wings for Men*. New York: The Century Company, 1932. 332 p. $4.00.

Beginning with man's first futile attempts to imitate the birds with wing-flapping devices, the author takes us through the various historical achievements to the present spectacular successes in air transportation. The book has these chapters: "The Beginning"; "The Balloon"; "Struggle"; "Bird-men or Power"; "Success"; "Progress"; "Rivalry"; "The Arena"; "War"; "Peace"; "Growth." It gives a very complete history of aviation and has numerous illustrations.

—W.G.W.

ENGLEMAN, F. E. and SALMON, JULIA. *Air Ways*. New York: D. C. Heath and Company, 1931. 180 p. $0.80.

This supplementary reader is suitable for third- or fourth-grade pupils. There is, of course, not much scientific explanation, but there are many things about the

airplane and its operation that are worth knowing. Besides, the little stories are interestingly told. The book is illustrated and has a list of "Things to Do" at the end of each chapter. —W.G.W.

BRINKLEY, STUART R. *Introductory General Chemistry*. New York: The Macmillan Company, 1932. 565 p. $3.00.

The author of this college text in chemistry has attempted "to limit the amount of specific descriptive and theoretical material and to arrange the order of the topics, so that the student may grasp the major developments of the subject, without becoming lost in a maze of details." Whether or not this aim has been accomplished, only its use in the classroom will determine. The organization of subject matter is quite different from that of the average, college-chemistry text. The classification of substances is based on the typical reactions which they exhibit. The salts are grouped according to type. A similar treatment is accorded the metals. The chapters dealing with these are as follows: "Nitrates"; "Halides and Sulfides"; "Sulfates and Phosphates"; "Carbonates and Silicates"; "The Active Metals"; "Metals Obtained from Oxide Ores"; "Metals Obtained from Sulfide Ores."

It would seem that little attention has been paid to organic and synthetic chemistry as only three brief chapters are devoted to this phase of chemistry. The book is intended primarily for the use of students who have had no preparatory work in the subject, although it may be used by mixed groups. —C.M.P.

KIRKPATRICK, J. E., and GREENE, HARRY A. *Pupil-Teacher Handbooks of Objective Test Exercises in High School Physics*. Bloomington, Illinois: Public School Publishing Company, 1931.

This is a series of five booklets and a Teacher's Manual. The booklets contain tests on the respective divisions of physics: mechanics, sound, heat, light, and magnetism and electricity. The tests consist of parallel, true, and false statements, multiple choice, and recall items. Only statements common to five, six, or seven current textbooks are included. The booklet on mechanics contains 153 pages of test items. The other booklets were not supplied to the reviewer.

The manual includes five chapters of explanation and discussion and answer keys for all test items. Chapter I discusses the need of source-books of objective exercises and explains how the exercises were prepared. All items were tested by administration to a group of 42 pupils. Chapter II discusses the use of objective exercises in the classroom, such as, daily quizzes, unit quizzes, reviews, problems, and examinations. Chapter III explains the systematic though somewhat complicated system of key numbers used. The two remaining chapters discuss the scoring of papers and assignment of class grades.

Teachers are expected to select test items to meet the needs of their classes although there is a logical arrangement of subject matter which may be adopted by the instructor if he so desires.

—A.W.H.

HEGNER, ROBERT W. *Practical Zoölogy*. New York: The Macmillan Company, 1931. 561 p. $1.80.

To the comparatively few secondary schools having courses in zoölogy, this revised edition of "Practical Zoölogy" will be quite useful. The author, who is a well-known zoölogist, emphasizes the ecological phases of the subject. The book is well written, fully illustrated, and scientifically accurate. Each of the major divisions of the animal world is discussed in turn. More complete and useful list of references might have been included. Biology teachers and elementary science teachers will find this book a valuable source of information. —C.M.P.

DARWIN, C. G. *The New Conceptions of Matter*. New York: The Macmillan Company, 1931. 224 p. $3.00.

This volume includes eight lectures, given by the author at the Lowell Institute of Boston, in which he tries to explain as clearly as may be done in a non-mathematical manner some of the latest conceptions of the structure of matter and the relations of the new conceptions to hitherto unexplained or imperfectly understood phenomena, such as polarization, magnetism, and electric conduction. In-

volved in these explanations are wave theories, the diffraction of matter, the uncertainty principle, collisions of free particles, and the exclusion principle.

The book should be of aid to the person who is attempting to simplify these complicated matters in his own mind and gain a more unified insight of the more detailed knowledge of the new mechanics.

—A.W.H.

CORMACK, MARIBELLE and ALEXANDER, WILLIAM P. *The Museum Comes to Life.* New York: American Book Company, 1931. 207 pages $0.76.

In this fascinating book the authors relate the experiences of a meadow mouse on its various visits to the halls of a museum of natural history. Meadow mouse gains entrance to the museum through an open window in the coal room, runs up the great stairs, and wanders through the broad quiet halls lined on either side with glass cases containing museum specimens of wild animals. He pauses before various animals, such as jumping mouse, bison, bat, raccoon, skunk, flying squirrel, chipmunk, woodchuck, snow shoe rabbit, lynx, shew, Arctic tern, golden eagle, garter snake, and salamander. As if by magic, each in turn comes to life and converses with meadow mouse about its family characteristics, life habits, home, enemies, and means of protection.

The book was written by Maribelle Cormack, head of the Children's Department, Park Museum, Providence, Rhode Island, and William P. Alexander, Hayes Professor of Natural Sciences, Buffalo Museum of Science. The authors know wild animals and also know how to present information about them in an interesting way for boys and girls. It is profusely illustrated with pen and ink sketches and charcoal drawings of the animals that talk with meadow mouse. The introduction was written by Mrs. Anna B. Comstock.

The book will be an inspiration to children and will tend to increase their interest in museums. It will strengthen the important working relationships which are being firmly established between museums and public schools. It is a delightful and worthy addition to the elementary-school library.

—F.G.B.

LAKE, C. H., and UNSELD, G. P. *A Brief Course in Physics.* New York: D. C. Heath and Company, 1931. 468 p. $1.68.

While this text is considerably smaller than most of the high-school texts in physics, it contains the essentials of elementary physics. By the introduction, the pupil is led through interesting physical facts into the real subject matter of physics. Under the headings "Mental Arithmetic," there is opportunity for plenty of mental exercise. In addition, there are the usual type of problems. At the end of the book are 117 review questions covering the entire book. The subject matter is that of the recognized high-school course. The book is well written and is attractive in appearance. It is illustrated with both line cuts and half tones.

—W.G.W.

GHIRARDI, ALFRED A. *Radio Physics Course.* New York: Radio Technical Publishing Company, 1931. 974 p. $3.50.

This is a very practical book for the person who wants to understand radio. It includes the underlying electrical and magnetic principles and the principles of sound involved in radio, radio broadcasting, television, and sound-motion pictures. The course is developed on the conception that a person may study radio even though he has not had the usual foundation courses in physics. The necessary elementary treatment of physical principles is given in very good style. The author who is an electrical engineer gives evidence of a thorough understanding of physics and chemistry and an acquaintance with the newly discovered physical and chemical concepts so useful in the explanation of radio phenomena. Many fine diagrams are included that are invaluable to the reader. The treatment is sufficiently practical to satisfy the technically minded and clear enough to please the novice. Most obsolete material has been omitted and the attempt has been well made to include the latest developments. It will be a welcome addition to the school and technical library, especially so to the radio enthusiast.

—A.W.H.

GHIRARDI, ALFRED A. and FREED, BERTRAM M. *Radio Servicing Course.* New York: Radio Technical Publishing Company, 1932. 182 p. $1.50.

The title of this book states the purpose for which it is intended, namely, to give useful information and some specific directions for radio service men. There are nine chapters dealing with simple electrical concepts related to radio and with the description and use of certain devices used in testing non-functioning radio sets. Many good photographs and diagrams are included to make these explanations clear. Radio enthusiasts will find in this book considerable information of value to them in making and testing their own sets.

—A.W.H.

CHIDESTER, F. E. *Zoölogy.* New York: D. Van Nostrand Company, 1932. 581 p. $3.75.

This is a survey of the field of zoölogy that will serve as a general introductory college course and will meet the needs of medical and agricultural students. The material has been used in mimeograph form by the author, specialists have studied critically the chapters relating to their respective fields, and outstanding scientists have criticized the content of the book as a whole.

Each chapter is organized to give the chief characteristics of animals in the group discussed; to give a logical arrangement of material relating to the animals within the group; and to give a summary of habitat, enemies, and economic importance of the animals considered. A list of carefully selected references that have been checked by experts is given at the end of each chapter. The general survey of the animal kingdom is followed by a chapter on "Social Life of Animals" and one entitled "Evolution, Heredity, Eugenics." —F.G.B.

CLELAND, HERTMAN F. *Geology—Physical and Historical.* New York: American Book Company, 1929. 718 p. $3.60.

Students interested in college geology will welcome this textbook. It gives the essentials of the science in a clear, concise, and interesting manner. It is profusely illustrated with excellent photographs, line diagrams, and block diagrams which contribute directly to the understanding of the geological principles. To assure accuracy of content, the materials in the book have been read and criticized by the authorities in the various geoglogical fields. In each chapter, carefully selected references are given for suggested, additional reading. This book is not only an excellent college text but also a source book valuable to lay readers. —F.G.B.

BRAY, W. C. and LATIMER, WILLIAM. *A Course In General Chemistry.* New York: The Macmillan Company, 1932. 159 p. $1.60.

This college book is a comprehensive manual which makes the laboratory work the central feature of the course. The student is put upon his own responsibility in the laboratory in order to develop ability to meet new problems and to fix the methods of scientific training. It favors "keeping the gifted student busy at his level of achievement." The main sections are: "Weight Relations in Chemical Reactions"; "Ionic Theory, Rapid Reversible Reactions and Equilibrium"; "Introduction to the Systematic Study of Ionic Reactions"; "Selected Problems in the Chemistry of Aqueous Solution"; "Qualitative Analysis." The appendix has a valuable list of reagents and strength of solutions to be prepared for general use.

—W.G.W.

HILDEBRAND, JOEL H. *Principles of Chemistry.* New York: The Macmillan Company, 1932. 388 p. $2.25.

The author has written this college text in the belief that it is good to "expose the student to far more material than the most of them can assimilate." This takes care of individual capacities when the whole of the material is not required for a passing grade. This revised edition has been brought up-to-date with the new chemical knowledge, but it is felt by the reviewer that a full explanation and use of the electron theory is desirable.

—W.G.W.

News and announcements

Teachers College, Columbia University, announces a course in Science and Science Education in Germany during the Summer Session of 1933. This work includes a tour through Germany with opportunity to study under the leadership of a biologist and a geologist. The tour will be organized by Dr. S. Ralph Powers, Professor of Natural Sciences in Teachers College, and is a regular feature of the offering for the Summer Session. A member of the staff in Natural Sciences in Teachers College will accompany the tour and direct the activities of the group. University credit up to six points will be allowed for this course. The work will begin in Bremen about July first and close at the end of six weeks in Hamburg.

An excellent series of lesson sheets in science for Grades I to XII, inclusive, has been completed and is now in use in the schools of Tulsa, Oklahoma, where Russel R. Spafford is the Director of Science.

The School Health Bureau, Welfare Division, Metropolitan Life Insurance Company, New York City, announces the publication of *Robert Koch,* a short biography of this great scientist. The new pamphlet is one of the Health Hero Series and is written for boys and girls. Copies may be had by writing to the Bureau.

Harry A. Cunningham of the Kent State College, Kent, Ohio, is engaged in a study of science laboratories in teachers colleges. He has investigated the laboratories of teacher-training institutions in Ohio, Michigan, Illinois, Wisconsin, Iowa, Missouri, and Indiana. He plans to expand the study to include certain other representative states.

Dr. Benjamin C. Gruenberg gave a course of six lectures at the Sixth World Conference of the New Education Fellowship held at Nice, France, during last summer. The titles of his lectures were:

Orientation in an Age of Science.

What Science is Doing to our Civilization.

How Science Affects Attitudes.

What Science Means for Educational Methods.

The Content and the Method in Science Teaching.

New Responsibilities of the Specialists.